Fertility decisions of women in the context of extreme climate events: A study in two areas hit by cyclones and floods in Bangladesh

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Abstract

This study investigates to what extent fertility decisions are influenced by extreme climate events in two villages in Bangladesh: Chadnimukha prone to severe cyclones and Lamagaon to floods. Extensive studies have examined the effects of extreme climate events on mortality and migration, but limited research attention has been paid to fertility. This thesis seeks to fill this knowledge gap by examining the fertility decisions of married Bangladeshi women and comparing the differences between the two villages.

The study uses a mixed methods approach (quantitative and qualitative analysis) to collect diverse types of information to understand the determinants of fertility in response to extreme climate events. In 2019 to 2020, through fieldwork, primary data were collected in household surveys (N=544) and in-depth interviews (N=74) from married women aged 18 to 49 years with at least one child who were living with their husbands. First, interviews (N=8) were undertaken with key informants and focus group discussions (N=10) were held with male participants to develop a comprehensive understanding of the extreme climate events, their impacts, and typical health issues in the study areas. Secondary data on fertility and extreme climate events were also collected from various sources, including the Bangladesh Meteorological Department, the Centre for Research on the Epidemiology of Disasters, and the World Bank.

This study found that women living in the flood-prone village had and intended to have more children than their counterparts in the cyclone-prone village, who were more likely to limit their childbearing. The number of cyclones experienced, household vulnerabilities, the timing of first birth, physiological effects, and seasonal migration tended to limit fertility. Floods, on the other hand, affected fertility due to lack of health facilities and unavailability of contraceptives, risk of infant mortality and preference for sons, which inspired women to have more children.

It was also found that the fertility intentions of women in both villages differed according to their experience and perception of extreme climatic events for which their villages were most at risk. In response to extreme climate events on household well-being, including agriculture, livelihoods, housing and food security, women were more likely to delay their next birth for at least two years. However, women from flood-affected households intended to have additional children in response to the effects of floods, either as an insurance measure for the household against the possible loss of a child due to a flood, or as a way to increase family livelihood and security where children could act as potential resources to help families deal with future risks.

This research concludes that the type of extreme climate event experienced can determine in what direction and to what extent fertility will change. It also contends that the impact of such events on underlying direct and indirect determinants that influence fertility is distinguishable, and that fertility considerations can and should be incorporated into disaster risk reduction and population policy. With the increasing frequency and severity of climate-related events, policymakers must understand how extreme climate events affect fertility rates in order to provide advice for social and economic development approaches. Furthermore, such information will help to generate population estimates, which can include the consequences of climate change at different stages of demographic change.

Keywords Fertility determinants, fertility intentions, household vulnerability, extreme climate events, health services, floods, cyclones, Bangladesh

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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- **Ahmed, K. J.,** Tan, Y., & Rudd, D. (2021). How does the households' vulnerability to climate–induced disasters influence women's fertility outcomes and fertility intentions in Bangladesh? Presented (poster) at the **International Population Conference (IPC)** of **IUSSP**, 5-10 December 2021.
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List of Acronyms

AIC	Akaike's Information Criteria
ASFR	Age–Specific Fertility Rate
BARC	Bangladesh Agricultural Research Council
BIC	Bayesian Information Criteria
BMD	Bangladesh Meteorological Department
CEB	Children Ever Born
CRED	Centre for Research on the Epidemiology of Disasters
CRI	Climate Risk Index
CVI	Climate Vulnerability Index
BDHS	Bangladesh Demographic and Health Survey
EM–DAT	Emergency Events Database
EWE	Extreme Weather Event
FDI	Family Dependency Index
FGD	Focus Group Discussion
FWA	Family Welfare Assistant
IDI	In–depth Interview
IPCC	Intergovernmental Panel on Climate Change
KII	Key Informant Interview
LDI	Livelihood Diversification Index
NIPORT	National Institute of Population Research and Training
TFR	Total Fertility Rate
TPB	Theory of Planned Behaviour
UzDMC	Upazila Disaster Management Committee
UDMC	Union Disaster Management Committee
UHFWC	Union Health and Family Welfare Centre
WHO	World Health Organisation

Chapter 1 Introduction and Background

1.1 Introduction

This study seeks to analyse the complicated relationship between extreme climate events and the fertility decisions made by Bangladeshi married women of reproductive ages. Bangladesh, one of the most densely populated countries in the world, is undergoing significant changes in its population structure, in part as a result of disruption to its economic, agricultural, and healthcare sectors by extreme climate events that can have lasting consequences that perpetuate underdevelopment (Shaluf, 2007), and, in turn, affect significant changes in population dynamics (mortality, migration, and fertility) (Jiang & Hardee, 2011). A great deal of research has already explored the impact of extreme climate events on mortality and migration as important population dynamics, but their impact on fertility has received limited attention.

Human geographers and social demographers have frequently documented the effects of climate variability or extreme climate events on health (Bakhtsiyarava et al., 2018; Grace et al., 2015; Rocque et al., 2021), migration (Gray & Wise, 2016; Hugo & Bardsley, 2014; Hunter et al., 2021; Tan, 2018; Tan & Liu, 2021) and mortality (De Waal et al., 2006; Psistaki et al., 2020; Yi & Chan, 2015). Anecdotal evidence suggests that, increasingly, people are debating the costs and benefits of being childfree as a response to climate change (or environmental change as defined more broadly) (Fleming, 2018; Miller, 2018; Relman & Hickey, 2019). To determine the extent of the effect climate change and extreme climate events have on fertility, it is necessary to conduct empirical studies to identify which determinants, triggered by extreme climate events and in conjunction with other demographic determinants, can influence fertility behaviour.

This chapter describes the background and context of this study and outlines the research questions. The nature of the research suggests that Bangladesh is a suitable study context, given the frequent occurrence of extreme climate events and considerable regional variations in fertility.

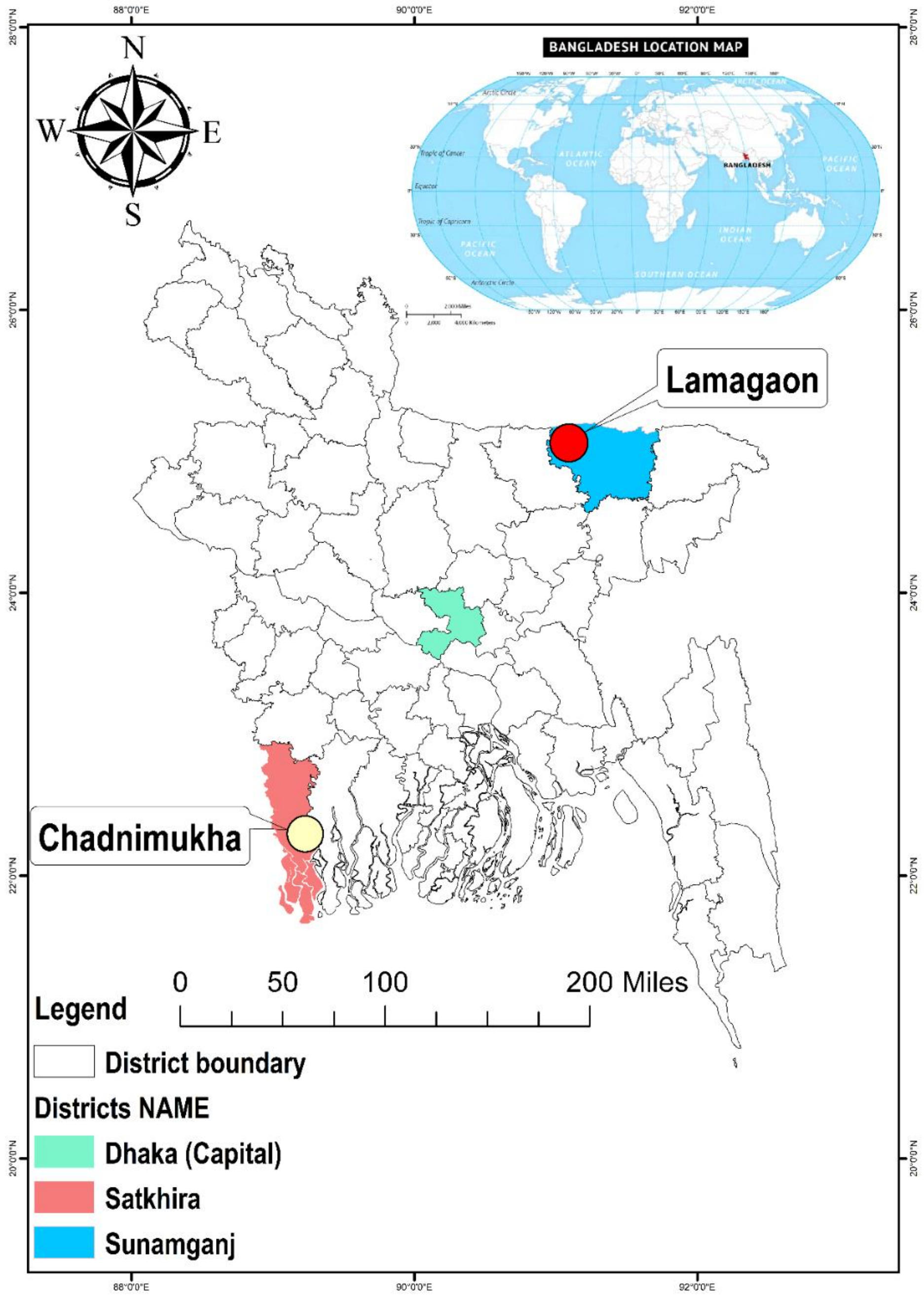
The climate of Bangladesh changes in alarming ways (Mohsenipour et al., 2018; Rahman & Lateh, 2017; Shahid et al., 2012), and extreme climate events were reported to be becoming more frequent (Salauddin & Ashikuzzaman, 2012; Shahid, 2010; Thakur et al., 2012), affecting various sectors in Bangladesh, such as agriculture (Hossain et al., 2019a; Barbour, 2022), food security (Chen et al., 2021; Sarker et al., 2012; Yu et al., 2010), and health (M. I. Kabir et al., 2016; R. Kabir et al., 2016). In Bangladesh, cyclones and floods are the most typically-experienced extreme climate events; cyclone-hit areas are primarily located in the southwest and flood-hit areas in the northeast parts of the country (Ahmed & Tan, 2021; Barua et al., 2016; Haque et al., 2021; Hossain et al., 2019b).

The distribution of fertility is uneven across Bangladesh, but, generally speaking, the areas with the highest recorded fertility (TFRs 3+) are concentrated in the north- and southeast parts of Bangladesh, while the lowest (TFRs 2.20) are found in the north- and southwestern parts (NIPORT et al., 2019).

Given the increasing vulnerability of different areas of Bangladesh to a range of climatic events, it is necessary to investigate how these events shape the socio-cultural settings and the demographic determinants that lead to differences in fertility. The study focuses on fertility in the context of climate change, specifically with respect to the impact of cyclones and floods, as these extreme climate events frequently occur in Bangladesh, are widespread across the country, hit densely-populated areas, cause the deaths and injuries of many people, make many people homeless, and inflict significant loss and damage (EM-DAT, 2022). Two villages were chosen from the southwest and northeast parts of Bangladesh, as shown in Figure 1.1, to examine and contrast the effects of specific extreme climate events on fertility decisions. ***Chadnimukha*** from the Satkhira district was chosen as a region hit by cyclones that has low fertility (TFR 1.79), and ***Lamagaon*** from the Sunamganj district was chosen as a region hit by floods that has high fertility (TFR 3.64). There are considerable differences between the study areas in terms of socio-economic and demographic determinants that have been widely recognised in earlier studies to explain the variations in fertility in Bangladesh (Alam et al., 2018; Islam et al., 2003; Kabir et al., 2008).

The selection of the study areas is discussed later in detail in Chapter 3. By conducting empirical research to examine the relationship between fertility and extreme climate events, this study contributes to and broadens the reach of the existing literature and provides useful considerations for policy makers both in Bangladesh and other climate-affected countries with similar demographics.

Figure 1.1 Location of study areas in Bangladesh.



Source: Author's own using ArcMap version 10.6.1.

1.2 Significance of the study

Populations are growing rapidly in many of the world's poorest and most susceptible countries to climate change and extreme climate events (Jiang & Hardee, 2011). It is widely accepted that changes in human fertility and reproductive health outcomes drive changes in the size, structure, and composition of a population, and that climate change and extreme weather events have an undeniable influence on human fertility and reproductive health outcomes (Casey et al., 2019; Muttarak, 2021). Grace (2017), in her study examining how the typical determinants of fertility shape the ability of poor communities to adapt to climate change, argues that, for two reasons, micro–level investigations into the connection between climate and fertility must be taken at the individual, household, and small community levels, by considering the relationship between extreme climate events and proximate and distal determinants of human fertility. First, she contends that there is a need for contextually relevant research to expand the understanding of global contemporary fertility change. Recent investigations purport that contemporary fertility decline–which is a part of the demographic transition–in consistent with mortality improvements, is not progressing as expected in certain contexts (Bongaarts, 2017; Bongaarts & Casterline, 2013; Cleland & Machiyama, 2017). For example, the concentration of higher fertility in sub-Saharan African countries (Roser, 2019; Shapiro & Hinde, 2017) and the slower pace of its decline has been unexpected. Second, the way(s) in which climate change may affect human fertility is not included when population estimations are being made. Therefore, the impact of climate change on human fertility is likely to be underestimated.

While research on climate impact on fertility is underestimated, there is an uneven geographical distribution of research on the disasters-fertility nexus, with the bulk of research focused on natural and human-made disasters conducted in developed countries. Based on secondary sources, a study of Hurricane Katrina in New Orleans showed that the effects of disasters on fertility come through different determinants such as displacement, access to reproductive care, and demand for children (Seltzer & Nobles, 2017). Lin (2010) also used secondary sources for his study in Italy and Japan and found a significant association between earthquakes and tsunamis and fertility behaviour in both countries. Another study revealed an increase in fertility after the 2004 Indian Ocean tsunami (Nobles et al., 2015). These studies, which demonstrated both spikes and declines in fertility rates in response to disasters, were limited in their reach. There remains a lack of empirical investigation into the relationship between extreme climate events and fertility, particularly as this relationship affects developing countries.

Though there is a growing body of research in this area from which to gain insights, the effects of disasters on fertility or intentions to have more children are mixed and ambiguous and demonstrate that fertility rates can either increase (Davis, 2017; Nobles et al., 2015) or decrease (Hamamatsu et al., 2014; Lin, 2010) in response to the disasters. An empirical investigation is needed to develop a scientific consensus about the effects of a disaster on fertility that can help to inform future population projections in times of climate change and the increasing occurrence of extreme climate events, as well as to make policy suggestions for disaster risk reduction and future health and population programs.

Demographers in Bangladesh have already examined how demographic, economic, social, and cultural determinants influence fertility. Some of the critical determinants identified are education (Akmam, 2002; Hossain & Karim, 2013), employment (Hossain & Karim, 2013), age at marriage (Ahmed et al., 2009; Nahar et al., 2013), contraceptive use (Bairagi, 2001; Islam et al., 2016; Mahmud & Islam, 1995; Saha & Bairagi, 2007), and socio-cultural settings (Rabbi, 2012). However, recent research in Bangladesh that has focused on the environment, climate change, or disaster dimensions and fertility dynamics (Chen et al., 2021; Haq, 2018; Haq & Ahmed, 2019) has called for a need to develop a better understanding of the variations in fertility that are likely to occur as a response to differences in the types of extreme climate events.

1.3 Research objectives and questions

The guiding objective of this research is to investigate how extreme climate events influence the fertility decisions of married women of reproductive ages (18–49 years) by conducting mixed methods research with groups of women from two villages that experience such events. The population participating in this research was limited to those who had at least one child and who were living with their husband at the time of the household surveys. An underlying objective was to observe and interpret any differences between regions with high and low fertility, in relation to extreme climate events. The district of Satkhira was selected as a cyclone-prone area with low fertility, and the Sunamganj district as a flood-prone area with high fertility. Two villages from the districts, **Chadnimukha** and **Lamagaon** were selected for comparison.

The specific objectives of this research are to:

1. Ascertain how the experiences and perceptions of extreme climate events have influenced women's fertility decisions.
2. Establish the ways in which rural households are vulnerable to extreme climate events and the extent to which this vulnerability has influenced fertility decisions in the past and will in the future.
3. Examine the extent to which women's fertility decisions are determined by demographic, economic, and social determinants and by extreme climate event-related determinants.
4. Determine how disruptions to infrastructure, transport, health and reproductive care, and contraception services during extreme climate events influence the fertility decisions of women.

The central questions of the study are: to what extent do cyclones or floods influence fertility decisions, and do fertility outcomes differ between areas hit by cyclones and those hit by floods? This study addresses the specific questions below:

1. Are the perceptions about climate change variability of the women surveyed consistent with meteorological records and the perceptions of their male counterparts? How do their experiences and perceptions of extreme climate events influence their fertility decisions?
2. Are the rural households in a cyclone-hit area and those in a flood-hit area equally vulnerable? How does household vulnerability to extreme climate events influence fertility decisions?
3. Are determinants associated with extreme climate events better able to explain the fertility decisions of women above and beyond established determinants of fertility?

4. How does access to infrastructure, transport, health and reproductive care, and contraception services influence the fertility of women at the time of extreme climate events?

1.4 Global trends in extreme climate events and fertility

There is growing scientific evidence and general agreement in the scientific community that the earth's climate and weather patterns have undergone a significant and long-lasting change, and that one of the consequences of this is an escalation and acceleration of the occurrence of extreme climate events (or extreme weather events) such as cyclones and floods (IPCC, 2022; Magnan et al., 2021). Climate scientists have offered confirmation and warnings that extreme climate events are likely to increase over time in frequency, intensity, and severity of impact on natural systems and population dynamics (e.g., mortality, migration, and fertility) (Fischer et al., 2021). Between 2000 and 2019, more than 11,000 extreme weather events were recorded worldwide: these caused the loss of over 475,000 lives and US$ 2.56 trillion (in PPP) (Eckstein et al., 2021). These extreme climate events are widespread, sudden, and intense, and many have exceeded the magnitude of previous observed and recorded events. The world has recently witnessed numerous noteworthy extreme climate events that have been historic in their severity: (a) in *2022*: floods in the east coast (Queensland and New South Wales) of Australia (Evershed & Nicholas, 2022); (b) in *2021*: floods in Germany and Belgium, wildfires in Greece, France, Spain, and some Balkan countries (CRED, 2021a); (c) in *2020*: floods in China, India, and Japan, Cyclone Amphan in India, Hurricanes Laura and Sally in the USA, Hurricane Eta in Honduras (CRED, 2021b), and heatwaves in Siberia (Overland and Wang, 2021); (d) in *2019*: Tropical Cyclone Idai in Mozambique, Zimbabwe, and Malawi, Typhoon Hagibis in Japan, floods in India, Afghanistan, South Sudan, and Niger (Eckstein et al., 2021); (e) in *2017*: Hurricane Harvey in Texas and Louisiana (Emanuel, 2017; Risser & Wehner, 2017).

Floods and cyclones top the list of extreme climate events, affecting human settlements and population dynamics worldwide. As illustrated in Figure 1.2, between 2000 and 2019, the world experienced approximately 85 percent more extreme weather events than it did between 1980 and 1999 (3,402 events 1980–

1999, 6,305 events 2000–2019), with storms (including cyclones) and floods occurring by far the most frequently. Of the top ten countries most affected by extreme climate events in 2019, five were hit by tropical cyclones, and four were hit by floods (Eckstein et al., 2021). Though floods were the most widespread extreme climate event worldwide in 2020, storms generated the most extensive loss and damage to the most people (45.5 million) and at the greatest cost (US$ 92.7 billion) (CRED, 2021b).

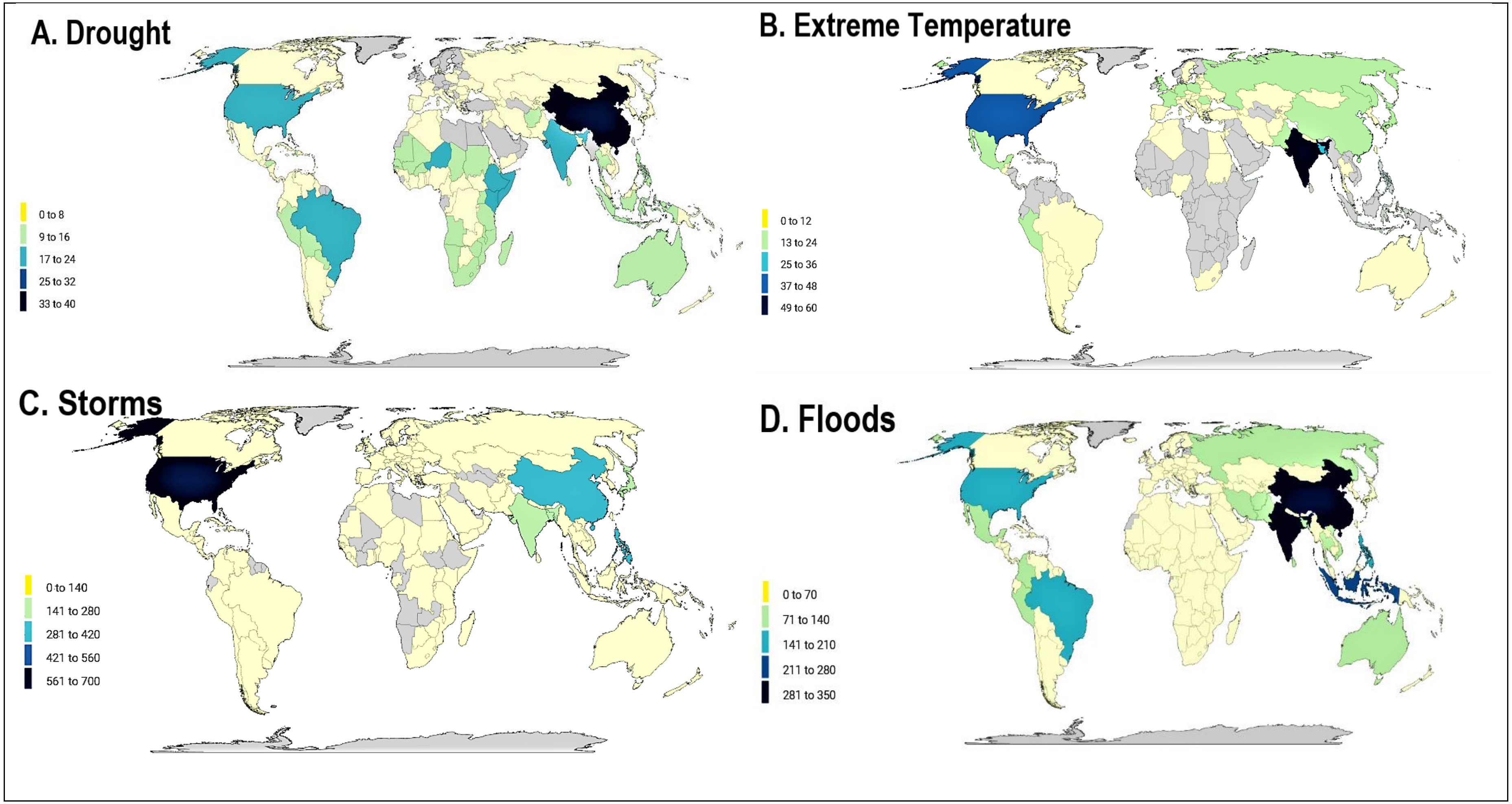
Figure 1.2 Total extreme climate events by type: 1980–1999 vs 2000–2019.

Year	Drought	Extreme temperature	Flood	Storms	Wildfire
					
2000-2019	338	432	**3254**	**2043**	238
	↑	↑	↑	↑	↑
1980-1999	263	130	**1389**	**1457**	163

Data source: CRED (2020).

There is an uneven geographical distribution of the impacts of extreme climate events, and populations in Asia bear the brunt of the increased frequency and the severity of such events, in terms of the number of people affected and killed. This is the case due to the unique geographical settings of Asian countries that include numerous floodplains, river basins, active seismic and volcanic zones, mountains, and high population densities in climate- or disaster-stricken areas. Global occurrences of extreme climate events such as drought, extreme temperature, storms, and floods are presented in Figure 1.3, which illustrates the extent to which Asian countries, particularly Bangladesh, China, and India face such events.

Figure 1.3 Global occurrences of extreme climate events: drought, extreme temperature, storms, and floods, 1900–2022.



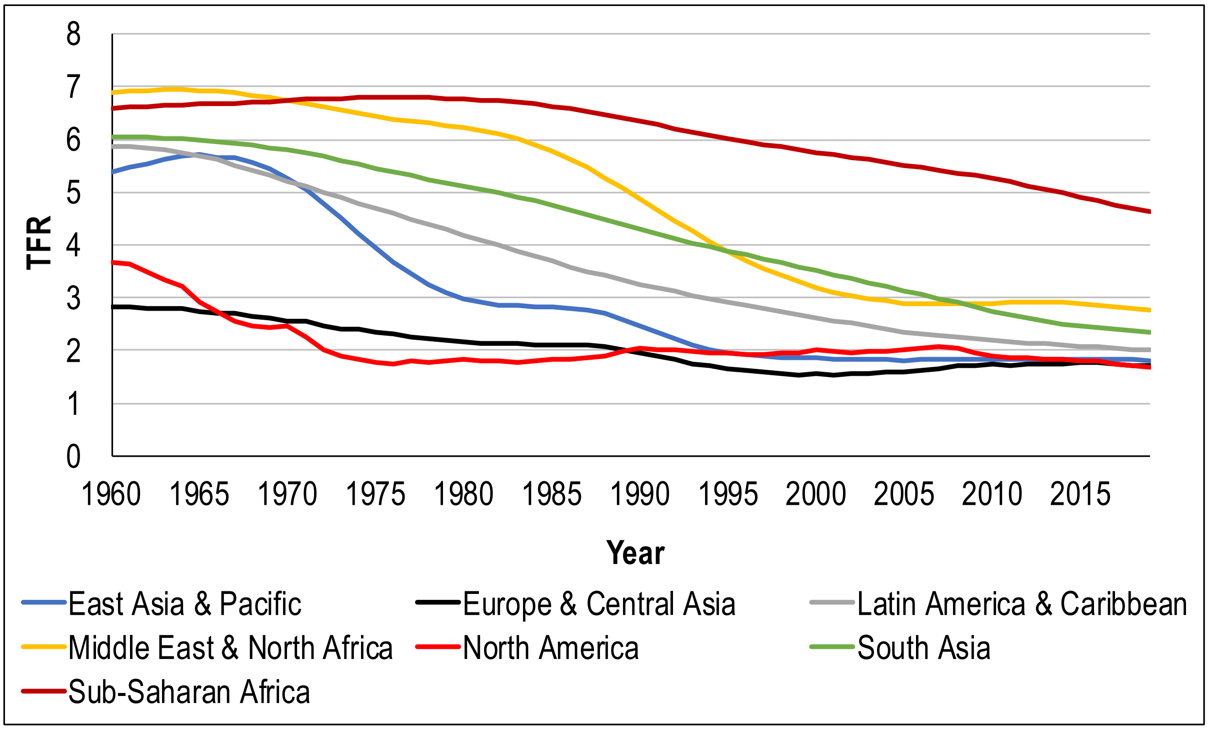
Source: Map generated by the author using the mapping tool and data from EM–DAT (2022).

In 2020, 41 percent of the world's extreme climate events and 64 percent of the people affected by climate events were in Asia (CRED, 2021b). Although people around the world are confronting the consequences of climate change (including extreme climate events), the adverse impacts tend to hit the poorest countries the hardest due to their frequent exposure, increased sensitivity, and poor adaptive capacity (IPCC, 2018, 2019; Jiang & Hardee, 2011).

Climate events can be measured by frequency, intensity, and severity. Population change can be measured with respect to alterations in total fertility rate (TFR), a mathematical estimation of the average number of children a woman (or group of women) would give birth to that would survive during her lifetime, if she were to pass through her childbearing years, depending on the age-specific fertility rates for a given year. Being the most commonly used standard measure of fertility, TFR can be employed to make comparisons between defined groups because it is a broad summary measure that is easy to understand, at least in general intuitive terms. Figure 1.4 shows the regional trends in fertility worldwide. A decline in fertility began in the mid-1960s across all regions except sub-Saharan Africa. Again, except for sub-Saharan Africa, the fertility trends in all areas have since continued to decline along similar pathways to rates between two and three, showing a general trend of fertility (or demographic) transitions. Fertility change in sub-Saharan Africa is unique: it began at the end of the 1980s with the second-highest TFR, just under 7, and has declined only slightly, in comparison to the other regions, to a TFR of 4.62 in 2019.

Though fertility decline in three aggregations–Europe and Central Asia, North America, and East Asia and Pacific–began at different times, all reduced to below-replacement-level fertility sometime between 1983 and 1993, before following a consistent decline to become countries with the world's lowest fertility. Latin America and the Caribbean reached a similar low level in 2014. Although the rate of decline in fertility has been much slower in South Asia than in these other countries, TFR in this region, too, has steadily dropped towards replacement rates, leaving the Middle East and North Africa and sub-Saharan Africa with the highest TFRs worldwide in recent years.

Figure 1.4 Regional trends in fertility, 1960–2019.



Data source: World Bank (2022).

Identifying the regions of the world that experience extreme climate events and the regional trends in TFR is a first step in delineating the intricate relationship between extreme climate events and human fertility that is deemed necessary in the under-researched field of environment-population relations (Xiao & Hong, 2010), and is arguably a significant ethical and policy imperative for poor or developing countries (Grace, 2017). To understand human vulnerability to extreme climate events at the household level and design effective climate adaptation and mitigation strategies, it is essential to consider fertility rates in areas susceptible to extreme climate events and variations (Jiang & Haedee, 2011).

1.5 Research context: Bangladesh as a case study

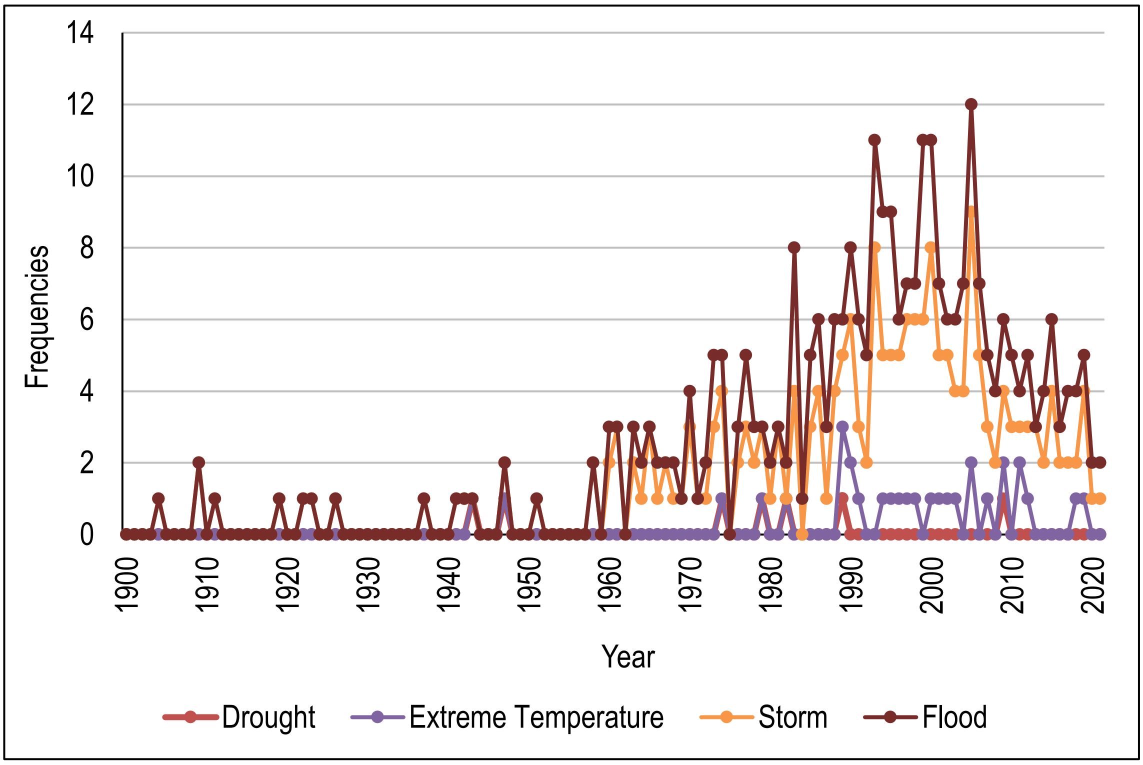
This section discusses the relationship between extreme climate events and fertility trends and differentials in Bangladesh, particularly in relation to the research fieldwork conducted in two areas that typically experience the most severe cyclones and floods in Bangladesh.

1.5.1 Extreme climate events in Bangladesh

Bangladesh is a South Asian country, neighboured by Myanmar in the southeast and India in the west, north, and east. Indian states narrowly separate Bangladesh from Nepal, Bhutan, and China. Bangladesh is divided into eight administrative districts, each of which is further subdivided into 64 districts. Climatically, Bangladesh is a sub-tropical region where monsoon weather characterises many parts of the country throughout the year (Shahid, 2008); thus, the overall climate of Bangladesh is referred to as *humid* (Shahid & Khairulmaini, 2009). Meteorological records have shown a significant increase in temperature and rainfall across Bangladesh (Mohsenipour et al., 2018; Rahman & Lateh, 2017; Shahid et al., 2012) , and these are projected to increase in the future (McSweeney et al., 2010; Rahman & Lateh, 2017).

According to the long-term Climate Risk Index (CRI) 2021, which ranks countries according to the extent to which they have been affected by extreme climate events, Bangladesh is ranked seventh among the top ten countries most affected, on average, between 2000 and 2019. This ranking is based on Bangladesh having experienced 185 climate-related extreme events that caused losses of US$ 1,860.04 (in million US$ PPP) during this period (Eckstein et al., 2021). Bangladesh has also been identified as the country most likely to suffer negative effects from droughts, heavy rainfall, floods, cyclones, and sea-level rise associated with anthropogenic climate change (Huq et al., 2019). Such extreme climate events are common in Bangladesh and have been increasing in frequency in recent decades, as shown in Figure 1.5. Of particular note is the marked increase in the occurrences of cyclones and floods in Bangladesh in the decades between 1980 and 2010. What can be clearly seen is that floods were the most frequently experienced event throughout the reporting period.

Figure 1.5 Frequencies of extreme climate events in Bangladesh by types, 1900–2021.



Data source: EM–DAT (2022).

As shown in Table 1.1, floods and storms have had the most impact in Bangladesh since 1900, in terms of the number of people affected by such events, the number made homeless, and the total costs associated with the damage incurred. While drought statistics presented in this table are high, most are associated with the Bengal Famine of 1943, which caused at least 1.9 million deaths in Bangladesh. According to Ayeb-Karlsson et al. (2016), the increasingly adverse impacts of extreme weather events in Bangladesh have led to tremendous loss of and damage to the life and assets of people living in vulnerable areas.

There are certain factors, such as its geographical position, its tropical monsoon climate, and its peculiar natural setting, which make Bangladesh vulnerable to frequent cyclones and storm surges (As-Salek, 1998; Madsen & Jakobsen, 2004; Paul & Rahman, 2006; Paul, 2009). It has been said that a severe cyclone occurs in Bangladesh almost once every three years (Ali, 1999). In 1970, a year before the independence of Bangladesh, there was a devastating cyclone (Category 3 storm) called the Great *Bhola* Cyclone. This cyclone was estimated to have caused 300,000 deaths, destroyed 400,000 households, and affected five million people (Frank & Husain, 1971). On the night of 29 April, 1991, a Category 5 storm called Cyclone *Gorky* caused 138, 000 (Bern et al., 1993) to 139,000 (USAID, 1991) deaths in the coastal lowlands of

Table 1.1 Records of extreme climate events for Bangladesh, 1900-2021.

Disaster type	Disaster subtype	Counts	Total deaths	Number injured	Number affected	Number of homeless	Total damage ('000 US$)
Drought	Drought in 1943	7	1,900,018	/	25,002,000	/	/
	Total	**7**	**1,900,018**	**/**	**25,002,000**	/	/
Extreme temperature	Cold wave	20	2,232	6,700	311,000	/	/
	Heat wave	2	62	/	/	/	/
	Severe winter conditions	2	230	/	101,000	/	/
	Not specified	49	5,706	30,697	2,114,660	211,500	1,572,249
	Total	**73**	**8,230**	**37,397**	**2,526,660**	**211,500**	**1,572,249**
Storms	Convective storm	40	2,168	31,441	1,190,650	248,000	61,324
	Tropical cyclone	93	627,051	876,580	75,755,937	7,697,768	10,944,840
	Not specified	38	45,418	100,120	195,254,563	3,452,724	1,298,877
	Total	**171**	**674,637**	**1,008,141**	**272,201,150**	**11,398,492**	**12,305,041**
Flood	Coastal flood	2	51	10	351,325	122,000	/
	Flash flood	11	261	280	7,534,297	100,000	1,120,715
	Riverine flood	46	7,278	23,080	138,031,767	589,938	11,862,296
	Total	**59**	**7,590**	**23,370**	**145,917,389**	**811,938**	**12,983,011**

Data source: EM-DAT (2022).

Bangladesh, from *Chattogram*[1] to *Cox's Bazar*, and on the coastal islands of *Sandwip* and *Kutubdia*. In 2007, after many regions of Bangladesh had already endured three months of being affected by a flood, Cyclone *Sidr* (Category 4) hit the coastal areas on the 15 of November, 2007; 40 percent of the total land area of Bangladesh was inundated and 1,100 people in the coastal areas died (UNICEF, 2007). In total, Cyclone Sidr affected around ten million people (Paul, 2009), caused total deaths estimated at 3,406 and resulted in over 55,000 injuries (GoB, 2008). The devastating Cyclone Aila, which hit the country on 25 May, 2009, affected coastal districts and inflicted widespread damage such as livelihood, food security, health, and critical infrastructure (Roy et al., 2009).

In addition to cyclones, Bangladesh experiences cyclonic, riverine, rainwater, and flash floods (Ahmad et al., 2001; Choudhury et al., 2004; Haque & El-Sabh, 2012). The type of floods experienced vary across Bangladesh (Brammer, 1990). *Cyclonic or storm surge floods* are associated with cyclones in the Bay of Bengal, and in the south-central and southwest regions (CCC, 2009; Choudhury et al., 2004). *Riverine flooding*, caused by heavy monsoon rainfalls and snow melts, mainly occurs in the *Ganga-Brahmaputra* basin area (Höfer, 2006). The people living in the floodplains of the *Meghna*, *Brahmaputra*, and *Ganges* Rivers are vulnerable to riverine floods (CCC, 2009), as water washes over riverbanks and spills across the land. The flood of 1988 was a riverine flood which occurred in the Ganga–Brahmaputra areas as a result of heavy monsoon rainfall (Brammer, 1990). River floods that occur early (June) or late (after mid-August) wreak colossal damage on crops (Brammer, 1990).

Although riverine floods can also be caused by monsoon rainfall, *rainwater floods* are a type of their own which result from extreme precipitation and affect low-lying regions and floodplains away from the main river courses, such as those found in the northeast part of Bangladesh (Höfer, 2006). The 1987 floods in the northern parts of Bangladesh are an example of rainwater floods resulting from heavy monsoon rainfall (Brammer, 1990). Severe *flash floods* typically occur in pre-monsoon months as a result of heavy rainfall onto the nearby hills in India (Brammer, 1990; CCC, 2009). These floods are characterised by a rapid rise and fall that usually occurs over a few hours or days. Because damage is associated with the flow of waters, flash floods do not usually induce damage to crops or assets (Brammer, 1990). The

[1] Note that, in April 2018, the government of Bangladesh changed the English spelling of five districts to avoid inconsistencies with Bengali spellings. The changes: Bogra to *Bogura*, Barisal to *Barishal*, Chittagong to *Chattogram*, Comilla to *Cumilla*, and Jessore to *Jashore*.

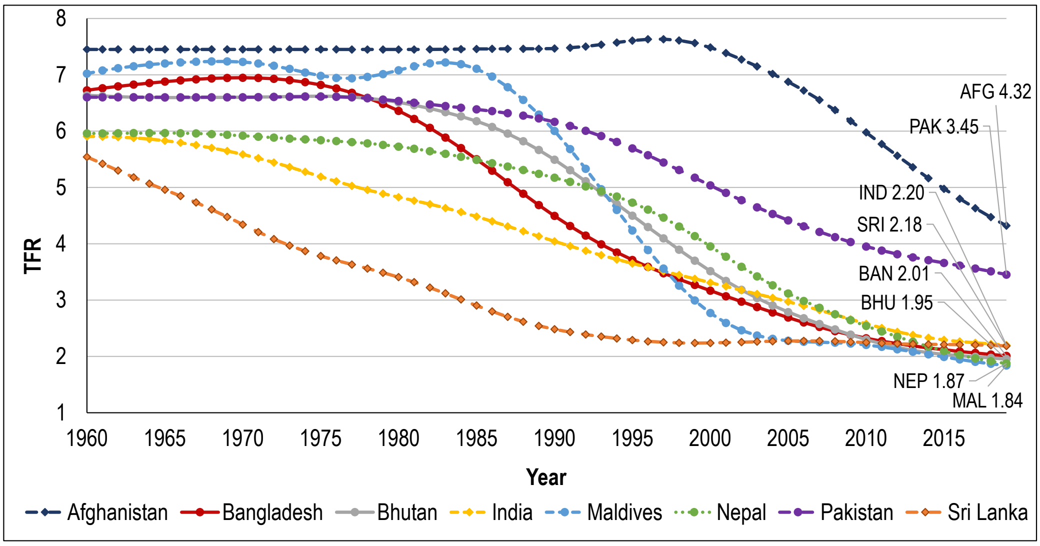
flash flood is atypical of other hazards, given their rapid onset and lack of early warning (Collier, 2007). The wetland communities of Bangladesh experienced particularly damaging flash floods in 1998, 2004, 2007, and 2012. The increasing intensity and variability of flash floods has been attributed to climate change (Guhathakurta et al., 2011).

Previous studies (Hallegatte et al., 2018; Hallegatte & Rozenberg, 2017; Olsson et al., 2014) have established that rural households in a country that are economically disadvantaged and generally depend on natural resources for their livelihood are likely to carry a more significant burden and are more vulnerable to the destructive effects of extreme climate events than wealthier people living in urban areas. People living in the coastal areas of Bangladesh, who typically farm and fish for a living and generally are of a low socioeconomic status, are increasingly suffering from the adverse weather events associated with climate change, including floods, cold waves, salinity intrusion, tornadoes, cyclones, and waterlogging (Hasan et al., 2018). It is not surprising, then, that households in these areas are experiencing loss and damage from exposure to extreme climate events, and it is likely that their vulnerability might influence household decision-making processes, including reproductive decisions.

1.5.2 Fertility trends and differentials in Bangladesh

Bangladesh has experienced a remarkable reduction in fertility since the late 1990s: from 6.4 births in 1980, to 3.4 births in 1997, to replacement level by 2019 (World Bank, 2022; Figure 1.6). As shown in Figure 1.6, this is one of the most dramatic and noticeable shifts in documented reproduction rates in developing countries, even when compared to other South Asian countries such as Sri Lanka, a country that was at the forefront of fertility change in South Asia. According to statistics from the World Bank (2022), the total fertility rate (TFR) started to fall in India in the 1970s, in Bangladesh, Bhutan, and Pakistan in the 1980s, in the Maldives in the late 1980s, and in Nepal in the early 1990s. Between 1960 and 2005, Afghanistan’s TFR remained steady at 4.32. Sri Lanka has seen the most significant reduction in childbirths since 1995, followed by Bangladesh, Bhutan, Nepal, the Maldives, and India, with Afghanistan and Pakistan seeing the least change. Bangladesh, Bhutan, and Pakistan all had approximately equivalent TFRs in 1960; but in 2019, Bangladesh was 2.01, Bhutan 1.95, and Pakistan 3.45. Of the South Asian nations, Bangladesh’s TFR in 2019 was lower than that of Sri Lanka, India, Afghanistan, and Pakistan. Total fertility rates in South Asia are lowest in the Maldives, Nepal, and Bhutan.

Figure 1.6 Trends in fertility in South Asian countries, 1960–2019.

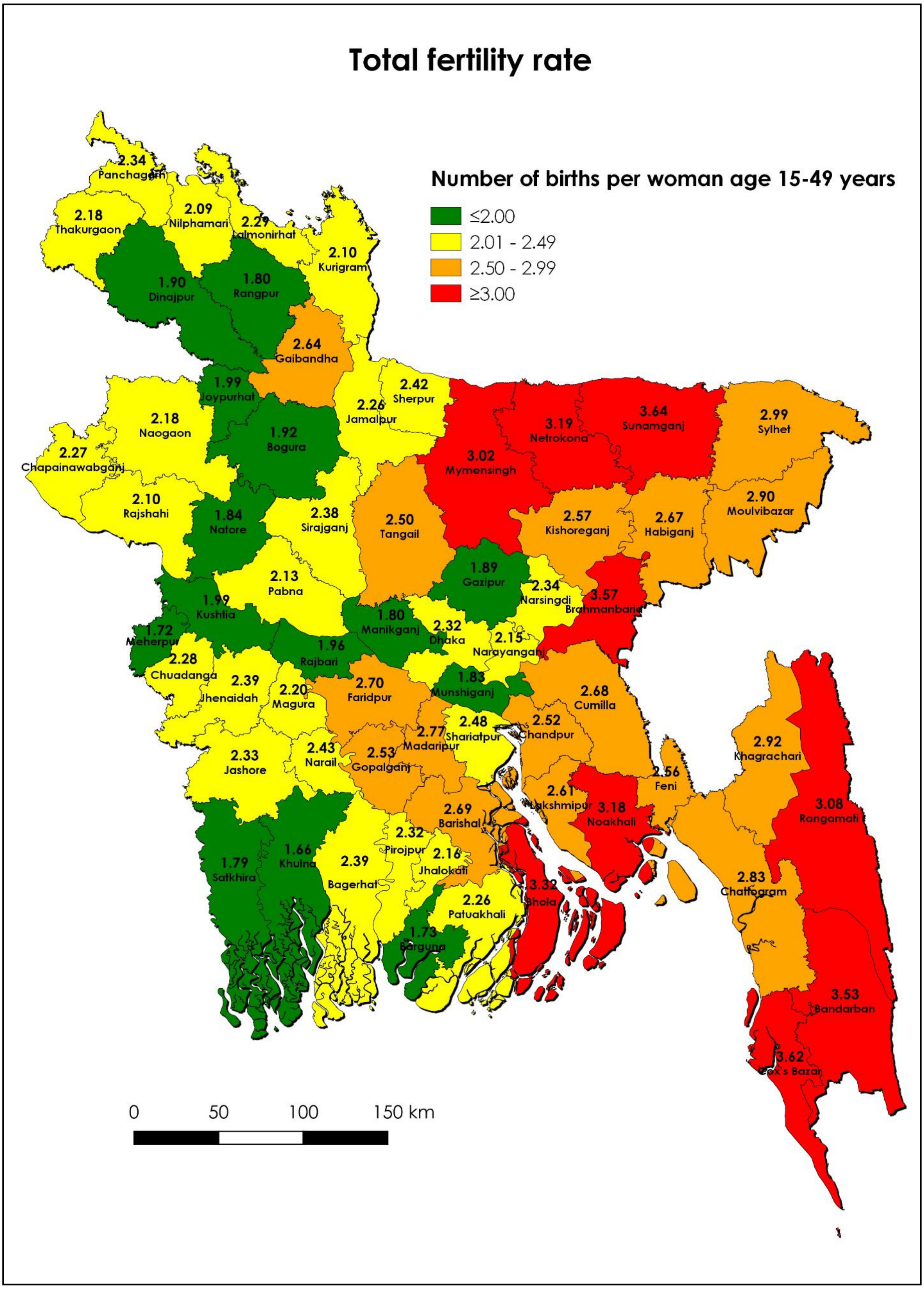


Data source: World Bank (2022).

A closer examination of the fertility rates within Bangladesh reveals substantial differences between rural and urban regions. Rural areas had higher birth rates (2.3) in 2018 than was the case for urban areas (2.0) (NIPORT & ICF, 2020). There are spatial variations of TFR in the country's eight administrative divisions[2] (Islam et al., 2010; NIPORT & ICF, 2020) and 64 districts (NIPORT et al., 2019). The Sylhet division, located in the northeast, has had the highest TFR (Islam et al., 2010; NIPORT & ICF, 2020) compared with other divisions. The differences in fertility across the 64 administrative districts of Bangladesh are shown in Figure 1.7. There are nine districts in which fertility is higher than three (TFR 3+), the highest being Sunamganj district (TFR 3.64). In contrast, 17 districts have achieved replacement level fertility, with the lowest TFRs in *Khulna* (1.66), *Meherpur* (1.72), *Barguna* (1.73), and Satkhira (1.79). Notably, more than half of the districts (38 in 64) in Bangladesh had fertility above the replacement rate (TFR 2.1) and below TFR at 3.

[2] Administrative units in Bangladesh are classified as Division, District and *Upazila* (sub-district). Each division is named after an important city in its jurisdiction, which also serves as the administrative headquarters of that division. Each division is divided into several districts, which are then divided into upazilas. Bangladesh has eight divisions with a total of 64 districts and 491 upazilas.

Figure 1.7 Differences in fertility between administrative districts in Bangladesh, 2018.



Source: Modified from NIPORT et al. (2019).

1.6 Thesis outline

This thesis comprises eight chapters. The first chapter has introduced the background of the research and contextualised Bangladesh as a case study area given its increasing vulnerability to extreme climate events and its regional variations in fertility rates. Chapter 2 provides an overview of the literature on how climate-related, natural, human-made, and biological disasters influence fertility rates. It summarises some important determinants associated with extreme climate events that can influence fertility behaviour and increase or decrease the fertility rates of a country. Chapter 3 details the mixed methods used in the study and the selection of the study areas used in fieldwork in Bangladesh. Chapter 4 provides profiles of the selected study villages utilising the community vulnerability and capacity analysis (CVCA) approach and household surveys, key-informant interviews, focus group discussions, and in-depth interviews.

Chapter 5 examines the perceptions of women surveyed about climate change variability and considers whether they are consistent with meteorological trends and how they coincide with the perceptions of males. It also assesses households' vulnerability to extreme climate events using an established climate vulnerability index (CVI) to identify the most vulnerable communities or the ones most at risk of climate change and extreme climate events. It raises the question of whether rural households in a cyclone-prone area are more vulnerable than those in a flood-prone area. Importantly, this chapter helps to understand how the vulnerability of households to extreme climate events can affect social, economic, health, livelihood, and food insecurity determinants that significantly influence fertility behaviour.

Chapter 6 deals with women's fertility in relation to the effects of extreme climate events, and presents the findings of the key research questions. It was found that women's fertility tends to differ between study areas hit by cyclones and floods, and the determinants associated with extreme climate events are likely to have different effects on fertility. The results of this study indicate that considering climate in studies on fertility differentials can add significant value to the discipline and to the established determinants which have been thoroughly investigated by demographers.

Chapter 7 focuses on how extreme climate events influence the fertility intentions of women, and presents the findings of key research questions on fertility intentions relating to direct and indirect determinants associated with cyclones and floods. It was found that cyclones and floods have varying impacts on the intentions of women to have more children in future, and that the underlying determinants associated with extreme climate events are distinguishable and able to, in conjunction with established determinants related to demographic, economic, social–cultural, and policy contexts, better explain the observed differences in fertility intentions.

Finally, Chapter 8 summarises the key findings with respect to the relationship between extreme climate events and women's fertility and their fertility intentions. The findings have implications for both disaster risk and family planning policy and future research in the areas of the theory of planned behaviour (TPB), human geography, and the impacts of COVID-19 on fertility. This chapter also addresses the limitations of the research and presents recommendations to inform governmental and non-governmental initiatives in health and socio-economic development.

Part of Chapter 2 has been published in the details below.

Statement of Authorship

Title of Paper	The disaster-fertility nexus in the context of Sub-Saharan African countries
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Principal Author

Name of Principal Author (Candidate)	Khandaker Jafor Ahmed		
Contribution to the Paper	Conceived and designed the analysis, collected data, reviewed literature, performed the analysis, interpreted data, wrote the manuscript, and acted as corresponding author.		
Overall percentage (%)	60%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	7/4/2022

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Yan Tan		
Contribution to the Paper	Supervised development of work, guided to conduct a systematic literature review, helped in data interpretation and presentation, and evaluated and edited the manuscript.		
Signature		Date	8/04/2022

Please cut and paste additional co-author panels here as required.

Chapter 2 Change in Fertility and Climatic, Natural, Human–Made, and Biological Disasters: A Review of the Literature

2.1 Introduction

Fertility, for any country, may be affected by biological, economic, social, environmental, and other determinants. Changes in fertility have typically been explored through the use of established determinants from demographic perspectives and theories. However, the effects of extreme climate events on human fertility have not received much attention from human geographers and demographers. A critical review of the available literature can help identify how fertility decisions are made in response to disasters and reveal the underlying determinants associated with changes in fertility.

It is particularly important for policy makers to understand how extreme climate events can influence fertility rates, so that they can make recommendations for economic and social development approaches to be taken in the context of increasing frequencies and intensities of climatic events. Moreover, such information will help generate population projections that can incorporate the effects of climate change through different phases of demographic transition. This chapter reviews the literature on changes in fertility in response to climatic, natural, human-made, and biological disasters and identifies critical processes influencing fertility behaviour. The following sections discuss conceptual and theoretical frameworks that have been used to examine the link between extreme climate events and fertility.

2.2 Determinants of fertility from a demographic perspective

Demographic perspectives have consistently been at the forefront among those seeking to explain changes in fertility. In the 1970s, Bongaarts (1978) formulated a framework for analysing the direct determinants of fertility which is still conceptually sound. Bongaarts took this framework a step further with colleague Potter (1983), explaining that social, economic, and environmental variables affect fertility through behavioural and biological determinants, labelled the proximate determinants of fertility. These proximate determinants, which are seen to be the closest to fertility events, have been used to explore the differences in fertility between different populations or trends in a country’s fertility level over time. The proximate determinants can be classified into two groups, namely: those that affect the length of the reproductive span, and those that affect the rate of childbearing during the reproductive span.

In detail, the two groups of proximate determinants can be broken down into a number of proximate variables. These include marriage (marital disruption), onset of permanent sterility, natural fecundability or frequency of intercourse, use and effectiveness of contraception, post–partum infecundability, spontaneous intrauterine mortality, and induced abortion. The first two of these seven determinants mark the length of the reproductive span, while the rest highlight the rate of child–rearing. The empirical evidence gathered at the time that these determinants and variables were developed showed that marriage, contraceptive practices, abortion, and postpartum infecundability had by far the most significant effect on fertility levels and differentials (Bongaarts & Potter, 1983). Generally, high contraceptive use is considered to most influence declining fertility across developing countries (Bongaarts, 2020; Bongaarts & Casterline, 2013, 2018), followed by changing marriage patterns and induced abortion (Majumder & Ram, 2015).

It is recognised that these established determinants based on demographic perspectives and theories have made a significant contribution to our understanding of changes in fertility. While some determinants (e.g., contraceptive use) have direct and indirect effects on fertility changes, an extreme climate event is also likely to be an important factor that can indirectly affect the proximate determinants and increase or decrease fertility rates. The following section reviews the literature to explore how several determinants are affected by extreme climate events and can change fertility.

2.3 How does fertility respond to disasters? A critical review of the literature

This section primarily examines whether fertility increases or decreases in response to climatic, natural, human-made, and biological disasters, which are discussed below.

2.3.1 Extreme climatic events and fertility

As detailed below, a number of studies have shown fertility rates to be responsive to extreme temperature events. Notably, it has been established that extreme temperatures can reduce birth rates. Researchers have demonstrated that increases in temperature reduced fertility rates, approximately after nine months, in South Korea and the USA (Barreca et al., 2018; Cho, 2020; Lam & Miron, 1996; Seiver, 1989). The extent to which birth rates changed in response to changes in temperature, according to these studies, is presented in Table 2.1. An increase in daily or monthly or seasonal changes in temperature significantly reduced birth rates after 8 to 10 months. The experience of a single day with a temperature of 30–32 °C (higher than the typical high temperatures of 28–30 °C) reduced birth rates in South Korea by 0.24 percent (Cho, 2020). Similarly, an increase in summer temperature by 1°C led to a .5 percent (Seiver, 1989) to 1 percent (Lam & Miron, 1996) decline in birth rates nine months later in many states of the USA.

Table 2.1 Change in birth rates and change in temperature.

Literature	**Change in temperatures**	**Change in the birth rates after (%)**		
		8 months	**9 months**	**10 months**
Seiver (1989)	+1°C (in summer months)		–0.50	
Lam & Miron (1996)	+1°C (monthly)		–1.00	
Barreca et al. (2018)	+One >80°F day	–0.05	–0.40	–0.21
Cho (2020)	+One >30–32 °C day		–0.24	

Source: Compiled from Seiver (1989), Lam and Miron (1996), Barreca et al. (2018), and Cho (2020).

Extreme temperatures can have short- and long-term effects on fertility rates. For example, in Bangladesh, an increase in the maximum temperature by 1 percent decreased birth rates by approximately 0.074 percent one year later and 0.048 percent two years later. Interestingly, three years after the maximum temperature had been exceeded, birth rates tended to increase (Chen et al., 2021). Extreme temperatures also affect the fertility intentions and family planning practices of women. In Indonesia, for example, women with farms were less likely to give birth and more likely to practice family planning following experiences of extreme temperatures; this effect was significant among poorer families (Sellers & Gray, 2019).

Not only temperature but also precipitation can impact fertility rates. While the temperature related events have tended to adversely affect fertility rates, precipitation events have been found to increase these rates. Extreme rainfall events were associated with increased birth rates in Bangladesh (Chen et al., 2021), Indonesia (Sellers & Gray, 2019), Mali (Philibert et al., 2013), Mexico (Simon, 2017) and Tanzania (Mulder, 1992). In Bangladesh, birth rates increased by 0.032 percent with a 1 percent increase in the maximum rainfall threshold. In Mexico, birth rates in the years following excessive rainfall were higher (e.g., 1.14 times) in the rural communities of arid zones than in those humid zones (Simon, 2017).

Storms such as hurricanes and cyclones are among the most frequently-experienced and deadliest extreme climate events worldwide. Table 2.2 shows that convective storms and tropical cyclones, primarily affect people in the least-developed and developing countries. The people of these countries tend to be more seriously affected by storms because of their higher population density and because they lack the necessary resources to respond to, recover from, and develop resilience to adverse effects. It is interesting to note that storm-related studies have revealed that fertility rates have been found to both increase (Cohan & Cole, 2002; Davis, 2017) and decrease (Antipova & Curtis, 2015; Grabich et al., 2016) following a hurricane or severe stormy weather. Following Hurricane Mitch in Nicaragua, birth rates increased over the short term and went back to normal within a few years (Davis, 2017). Similarly, fertility rates increased in the affected areas in the years following Hurricane Hugo, which hit South Carolina in 1989 (Cohan & Cole, 2002). In contrast, the lower births were reported in almost all months for the years following the 1992 occurrence of Hurricane Andrew, which affected Louisiana state (Antipova & Curtis, 2015). The results of these studies are not transferrable to developing or least-developed countries, and it is not possible to make generalisations about the uniform effects of storms on changes in fertility rates.

Table 2.2 Top 10 countries affected by convective storms and tropical cyclones and total numbers of people affected, 1900–2022.

Sl No.	Convective storms		Tropical cyclones	
	Countries	**Total affected**	**Countries**	**Total affected**
1	China	193,011,242	China	266,738,698
2	The USA*	85,554,360	The Philippines	193,823,473
3	Moldova Rep.	2,625,580	India	143,378,003
4	Israel*	2,003,200	Bangladesh	86,330,285
5	Bangladesh	1,470,091	Vietnam	55,549,104
6	Lebanon	1,116,776	Cuba	21,965,701
7	Pakistan	1,002,038	The USA*	15,734,270
8	India	816,571	Madagascar	10,735,297
9	Mongolia	776,624	Japan*	8,303,856
10	Albania	525,000	Honduras	8,127,956

Note: * Developed countries.
Data source: EM–DAT (2022).

Floods are also among the deadliest extreme climate events worldwide and, as shown in Table 2.3, are more likely to affect a higher number of people than other climatic events do, particularly in the least-developed and developing countries. The effects of flooding can hinder the sustainable development of affected areas (CRED & UNDRR, 2020; Hallegatte et al., 2016). The global population exposed to floods increased from 58 to 86 million between the years 2000 and 2015. Flood events are primarily concentrated in Asia, followed by the Americas, Africa, Europe, and Oceania. Since 2000, an estimated 255 to 290 million people have been exposed to at least one flood, most of which (90%) have occurred in South Asian countries (Tellman et al., 2021). Birth rates were found to be responsive to floods, as shown by a single study conducted in the USA by Tong et al. (2011), which revealed a number of changes in birth rates and outcomes (as well as pregnancy risk factors) following the 1997 Red River flood in North Dakota. In summary, birth and fertility rates decreased, but there was an increase in the number of older, more highly-educated, unmarried, and non-white women giving birth. The Red River flood was also followed by increases in birth-related problems. More empirical research is needed to understand how floods in developed, developing, or least-developed countries can influence fertility behaviour and outcomes.

Table 2.3 Top 10 countries affected by riverine, flash, and coastal floods and total numbers of people affected, 1900–2022.

Sl No.	**Riverine floods**		**Flash floods**		**Coastal floods**	
	Countries	**Total affected**	**Countries**	**Total affected**	**Countries**	**Total affected**
1	China	1,743,293,866	China	91,220,934	India	11,500,000
2	India	348,864,849	India	48,681,710	Vietnam	4,353,316
3	Bangladesh	138,644,785	Pakistan	22,114,350	China	1,000,015
4	Thailand	40,044,639	Bangladesh	7,634,577	Mexico	746,060
5	Pakistan	34,967,357	Thailand	7,621,118	Mozambique	649,329
6	Vietnam	25,637,158	Philippines	6,258,389	Malawi	518,500
7	The Philippines	14,633,799	Sri Lanka	2,449,382	Bangladesh	473,335
8	The USA*	11,988,747	Indonesia	2,022,890	Japan*	384,143
9	Cambodia	11,984,258	Turkey	1,357,494	Russia*	307,181
10	Brazil	11,418,683	Iran Rep.	1,328,441	The Netherlands*	300,000

Note: * Developed countries.
Data source: EM-DAT (2022).

Fertility is also responsive to drought and associated famine. Fertility rates have been found to decline following droughts in Bangladesh, China, Ethiopia, Finland, and Tajikistan (Ashton et al., 1984; Cai & Feng, 2005; Clifford et al., 2010; Coale, 1981; Fellman & Eriksson, 2001; Lindstrom & Berhanu, 1999; Razzaque, 1988). Rates of conception declined during the drought-induced famines between 1970 and 1980 in Ethiopia (Lindstrom & Berhanu, 1999), between 1967 and 1968 in Finland (Fellman & Eriksson, 2001), and between 1958 and 1961 in China (Ashton et al., 1984; Coale, 1981). Results from these studies indicates that the reproductive health of women deteriorated as a result of droughts. However, fertility rebounded within two to four years following drought crises in Bangladesh (Razzaque, 1988), China (Coale, 1981), and Finland (Fellman & Eriksson, 2001). For example, in China, the birth rate (per 1,000) before the great famine was 35.7 in 1950–1957; it dropped to 23.8 during the famine (1958–1961), and increased to 35.9 during the post–famine period between 1962 and 1971 (Coale, 1981). Razzaque (1988) found in Bangladesh that the total fertility rates across different socioeconomic groups dropped during the famine and rebounded in the following years, and the effect was particularly noteworthy for poor families.

In addition to waterways, oceans, and the atmosphere, the crust of the earth is being affected by climate change, and there has been an increase in earthquakes, volcanic eruptions, and tsunamis. Earthquake–related studies conducted in different contexts in China, Haiti, India, Italy and Japan revealed mixed effects on fertility (Behrman & Weitzman, 2016; Hamamatsu et al., 2014; Lin, 2010; Nandi et al., 2018; Tan et al., 2009; Zhu et al., 2013). Studies conducted in diverse settings in Asia, Europe, and the Americas show that earthquakes affect total fertility rates positively (Behrman & Weitzman, 2016; Carta et al., 2012; Nandi et al., 2018; Zhu et al., 2013). In India, following the 2001 Gujarat earthquake, the childbirth rate increased in the earthquake-affected areas more than it did in the neighbouring unaffected areas (Nandi et al., 2018).

However, earthquakes had adverse effects on birth rates in two East Asian countries: China and Japan (Fukuda et al., 1998; Hamamatsu et al., 2014; Tan et al., 2009). Although the economic and policy contexts of these two countries differ, it has been argued that they have now converged to form a geographic cluster with common socio-cultural milieu and the world's lowest level of human fertility (Tsuya et al., 2019). Following an earthquake in 2011 in Japan, there was an observed lower birth rate after nine months, in both the disaster-stricken and non-disaster-stricken areas (Hamamatsu et al., 2014). Fertility rates declined by 6 percent nine months later following the Kobe earthquake in Japan in 1995 (Fukuda et al., 1998).

Similarly, fertility rates declined by 4.29 percent following the Wenchuan earthquake in China in 2008 (Tan et al., 2009).

2.3.2 Human–made, technological disasters, and fertility

In population studies, war and conflict are categorised as human-made disasters which have been found to have had mixed effects on birth rates in many study areas, both during and after such disasters. The critical review of the literature on human-made disasters and fertility shows that the fertility rate typically decreases during disasters and rebounds in the following years. During the period of genocide led by the Khmer Rouge regime in Cambodia from 1975 to 1979, the total fertility rate (TFR) declined by 29 percent compared to the rate before this period. However, after the Khmer Rouge government was overthrown (1979–1980), there was a massive spike in the TFR, with over seven live births per woman, a rate 91percent higher than that between 1976 and 1978 (Heuveline & Poch, 2007). After the Second World War, the European and non-European countries that had been engaged in the fighting experienced a baby boom (Van Bavel & Reher, 2013). In Italy, after the Second World War, the fertility rate increased for two decades and then declined dramatically over subsequent decades (Franklin & Plane, 2004).

Other studies confirm the tendency of total fertility rates to decline significantly during wartime. Birth rates also declined dramatically during the 1762 to 1764 war in Colombo, Sri Lanka (Drixler & Kok, 2016), the 1992 to 1995 civil war in Bosnia and Herzegovina (Pobric & Robinson, 2015), and the 1992 to 1997 civil war in Tajikistan (Hohmann et al., 2010).

The effects of human-made disasters on fertility rates have been found to be particularly acute in very hostile areas. Using nationally representative survey data from 1996, Agadjanian and Prata (2002) revealed that, following the very aggressive rounds of war in Angola between 1992 and 1994, women from the more-affected areas were significantly less likely than those from the less-affected areas to become pregnant in the following 12 months. Similarly, Lindstrom and Berhanu (1999) observed a sharp decline of conception probabilities in urban areas in Ethiopia in the 1980s, where the civil and political unrest was centralised and intense. The 1971 civil war in Bangladesh also induced a rapid decline in fertility rates in the affected region (Curlin et al., 1976).

2.3.3 Biological disasters and fertility

The bulk of the fertility research into the effects of biological disasters, in which naturally occurring micro-organisms cause widespread disease, disability, or death, has focused on the impacts of epidemics or pandemics – primarily HIV/AIDS. Heuveline (1997) demonstrated that fertility decline was associated with the AIDS pandemic in sub-Saharan Africa. The author distinguished the impact of that pandemic on fertility among infected women from that on the general population. With an average infection rate of 30 percent of women of reproductive age, a 10 percent decrease in the fertility rates of the infected women led to a 3 percent decrease in fertility overall. Hunter et al. (2003) examined the association between HIV and the fertility of women in a rural area of Tanzania. They observed a substantial reduction in the fertility of infected women compared to uninfected women. Data from two different surveys they conducted revealed that women who were either infected or of unknown status in the first round but definitely infected in the second round had their fertility halved in the second round compared to their counterparts who were uninfected in both rounds. However, among women aged between 15 and 19 years, fertility was higher for those who were HIV positive than for those who were HIV negative.

Castro et al. (2015) examined how HIV risk perception influences women's fertility intentions. They found a negative association between women's perceived risk of HIV and their intention to have a child in the following two years. Their findings revealed that the probability of giving birth declined by 25 percent when the perception of HIV risk shifted from "low" to "high".

Marteleto et al. (2020) examined the effects of the Zika epidemic on live births and fertility in Brazil. The first epidemic of Zika was confirmed on 22 May, 2015, in the State of São Paulo in Brazil, and on 11 November, 2015, the authorities of Brazil formally announced a National Public Health Emergency due to the observed rise in microcephalic cases associated with this virus in the northeast states of Pernambuco, Paraiba, and Rio Grande do Norte. Brazil experienced a dramatic fall in birth rates in July and August of the following year, nearly nine months after the declaration of the health emergency. Spatial variations in Brazil's fertility rate occurred, and the decline was more severe in Northeast Brazil than that experienced in the south because of the severity of the epidemic in the northeast. The higher the exposure level to the virus, the more significant was the impact on female intentions and activities to regulate fertility.

2.4 Effects of disasters on the determinants of fertility

This section reviews literature on how different disasters can change fertility rates. As will be discussed, the same type of event can have multiple effects: some determinants (e.g., frequency of intercourse, a lack of access to contraceptives, and child mortality) associated with particular events have been found to increase fertility, while others (e.g., changes in socio-economic condition, disruptions in marriage, increase migration, and increasing experience and concern about disasters) reduce fertility.

The “hunkering down” that often follows a disaster can potentially increase fertility rates among the affected populations. For example, Cohan and Cole (2002) linked the post-hurricane fertility increase identified in South Carolina, USA, to the bonding time couples spent together during and after the event (Cohan & Cole, 2002). Carta et al. (2012) found that, after the 2009 earthquake in L’Aquila, Italy, the sexual drive, moments of physical closeness, and frequency of intercourse reported by the couples they studied had increased by 18.6 percent, 36.2 percent, and 14.4 percent, respectively (Carta et al., 2012).

Another important factor to consider is access to family planning services and contraceptives, which can be influenced by a disaster. A lack of access typically leads to unplanned pregnancies and subsequent births. Some insights from reported experiences of the COVID-19 pandemic shed light on the ways in which a disaster or pandemic can disrupt delivery of contraceptive services and products and subsequently increase birth rates. It was reportedly difficult for couples to access family planning services during the 2020 COVID-19 lockdown in many parts of the world. For example, Marie Stopes International, which offers family planning services, was forced to close the clinics it operated in India and Nepal under the lockdowns (Marie Stopes International, 2020). In addition, there was a shortage of contraceptives during the pandemic, as the manufacture of critical pharmaceutical components of contraceptive methods was heavily disrupted (Purdy, 2020). Estimates reveal that an additional 15 million unintended pregnancies could occur in 132 low- and middle-income countries as access to short- and long-term contraceptive methods declined by 10 percent because of the COVID-19 pandemic (Riley et al., 2020).

Fertility rates typically rise in response to child mortality. Children, particularly younger ones, are at increased risk during climatic or natural disasters or pandemics. For example, in 1918, children and young adults were at increased risk of the “Spanish flu” (Luk et al., 2001). In 2018, 67 percent (272,000) of all malaria deaths were children (WHO, 2020). Findings associated with the 2004 Indian Ocean tsunami present an example of the relationship between fertility rates and child mortality: the fertility rates were high among the Indonesian parents who had lost their children during or due to this tsunami. Reportedly, these parents considered having more children as insurance against the anticipated risk of the death of children (Nobles et al., 2015).

Changes in socio-economic conditions resulting from disasters also have an impact on fertility rates: those associated with a famine in Finland in 1867-1868 were explained as a critical contributor to the decline of births in that country (Fellman & Eriksson, 2001). Following the earthquake of 2011 in Japan, there was an observed decline in birth rates after nine months in both disaster-stricken and non-disaster-stricken areas. Though the marriage rate was also lower during this period, the post-earthquake socioeconomic conditions experienced across the country were reckoned to be critical to this birth decline (Hamamatsu et al., 2014). Responses of fertility to the war in Angola from 1992 to 1994 were tied to socioeconomic determinants regardless of location within this country: women with more education and greater affluence were better able to regulate their fertility during and after this period (Agadjanian & Prata, 2002).

Increases or decreases in the incidence of marriage during or after disasters can influence fertility rates in societies where marriage is a necessary condition for sexual intercourse and having children. The increased prevalence of early marriage during the Iraq war from 2003 to 2010 was determined to have been the cause of the higher fertility rates among younger women observed at that time (Cetorelli, 2014). Similarly, the higher TFR recorded following the end of the Khmer Rouge regime in Cambodia from 1975 to 1978, was, according to Heuveline and Poch (2007), due to a boom in marriage at that time and high marital fertility. In contrast, the rapid decline in fertility following the 1971 civil war in Bangladesh was argued to have been caused by the disruption of marriage during the war (Curlin et al., 1976).

According to Blanc (2004), the labour migration resulting from Eritrea's 1998 to 2000 border conflict with Ethiopia explained the decline of fertility in Eritrea between 1995, when the TFR was 6.1 per woman, and 2002, when it was 4.8 children per woman. Demographic and Health Survey (DHS) data from 1995 and 2002 revealed that six in ten and three in ten married women, respectively, were residing with their husbands. This change in living situation was attributed to the massive mobilisation of men to join the fighting: 55 percent of the women surveyed in the 2002 DHS reported the occupation of their husbands as in the military. In 1995, this occupation was only held by the husbands of 9 percent of the women surveyed.

Another type of migration that affects both livelihood and fertility rates is driven by extreme climate events, which prompt within- or outside-country migration (Carrico & Donato, 2019; Roeckert & Kraehnert, 2021). Simon (2017) argued that the best possible explanation for increased fertility following above-average precipitation in Mexico was drought-induced migration. The author argues that during droughts in the arid regions, households choose to relocate short-term to look for work. Once the environmental conditions improve following the above-average precipitation, households tend to return home where they can work productively on farms that, once again, have adequate water. Therefore, the absence of migration following the above-average precipitation could be a pivotal contributor to the increased fertility in dry rural communities in Mexico.

The experience of a disaster can lead individuals to learn and update their previous expectations about risk and subsequent behaviour (Adger et al., 2013; Palmer & Smith, 2014). At the same time, the adaptive behaviours of an individual are influenced by their perception and experience of such disasters (Dillon et al., 2011; Silver & Andrey, 2014). Given the relationship between disaster experience and behaviour, it can be expected that living through a disaster is likely to impact women's fertility behaviour, either increasing or decreasing the likelihood that they will decide to have children. As noted above, women in Indonesia decided to have more children following the loss of children during or as a result of a 2004 tsunami (Nobles et al., 2015). Agadjanian and Prata (2002) reckoned that the significant decline in reproduction in Angola following rounds of war between 1992 and 1994 was associated with the women's experiences or memories of the war and their expectations of the probability of its return.

Declines in fertility following climatic and biological disasters may well be associated with behavioural and biological drivers. Cho (2020) argues that reductions in birth rates following high temperatures could be explained simply by heat-related fatigue reducing coital frequency. However, Hajdu and Hajdu (2019) examined the effects of surrounding air temperature on sexual activity in Hungary, which is located in the Northern and Eastern hemispheres and has a continental climate. They concluded that hot temperatures in Hungary do not significantly affect sexual activity either on a given extremely hot day or on subsequent days. However, they also reported an observed seasonality of sexual activity, with the lowest in July and December and the highest in November. Cho (2020) argues, from a biological perspective, that the likelihood of conception may decrease due to a worsening of female health at conception caused by extreme temperatures. Reduced sperm concentration as a consequence of elevated temperatures is another possible factor, but the place of male physiology and male fertility in this complex causal network is so far under-researched and was barely touched on in the literature reviewed. Fukuda et al. (1996) showed that sperm motility among men whose homes had been destroyed by the 1995 earthquake in Kobe was greatly reduced less than a month after the event, but then recovered within 2 to 9 months. Fukuda et al. (1998) later argued that the intense stress caused by the Kobe earthquake had affected the fertility of the male population, due to the rapid decrease in sperm motility and response to low fertility after 9 months.

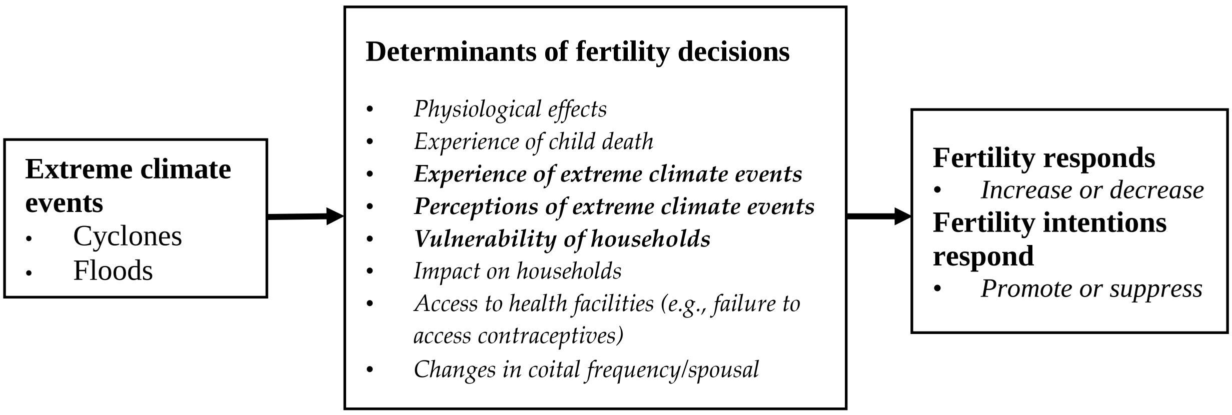
In line with the arguments of Cho (2020), Daniel (2000) and Hunter et al. (2003) attributed the reduction in fertility associated with the HIV/AIDS epidemic to behavioural and biological causes. The behavioural perspective indicates that HIV-positive women may have infrequent sexual intercourse or none at all or are more likely to use methods to avoid the risk of infection and therefore of conception (Daniel, 2000; Hunter et al., 2003). In contrast, the biological perspective explains that decreased fecundity (Hunter et al., 2003) and increased morbidity (Daniel, 2000) associated with HIV lower both opportunities for conception and fertility levels. According to the study by Terceira et al. (2003) of HIV-infected women in Zimbabwe, other determinants driving their lower fertility were reduced coital frequency and contraceptive use. Modern contraceptives were less likely to be used by infected women because they had either decreased their coital frequency or were experiencing increased amenorrhoea.

Heuveline (1997) also articulated the possible indirect effects of the AIDS pandemic on fertility declines in general, surveying additional proximate determinants. First, the ability to become pregnant could be influenced by the degree to which the couple is affected by the disease. A couple might voluntarily decrease their frequency of sexual intercourse if either partner was HIV infected; the death of one of them may mean, of course, that the partnership was in fact dissolved. Second, the decreased fecundity may be symptomatic of HIV infection itself. Third, in a crisis situation as could be due to HIV infection, the couple might turn away from their customs and traditional religious values and prefer longer birth intervals. Last, the decline in fertility might result from the increased use of birth control measures, some of which are used as measures against infection with HIV.

2.5 Conceptual framework: Nexus between extreme climate events, determinants, and in what ways fertility decisions respond

This section describes the core components of the research: extreme climate events, determinants of fertility decisions, and in what direction such decisions respond. A conceptual framework was developed to address the relationships between these components. Figure 2.1 represents how extreme climate events, in the case of this research, cyclones or floods, *directly* or *indirectly,* influence the determinants of fertility behaviour and, in turn, increase or decrease people's fertility and promote or suppress their intentions to bear more or fewer children in the future.

Figure 2.1 A conceptual framework describing the relationship between extreme climate events and determinants of fertility decisions.



The literature review has clearly shown that the effects of climatic, natural, human-made, and biological disasters on fertility and fertility decisions are not uniform: in response to a given disaster, fertility increases in some areas, while it decreases in other regions, depending on the national and regional contexts. Considering the review of research findings in a variety of contexts, important determinants for fertility responses to disasters can be summarised as follows:

- crisis-induced psychological stress (Fellman & Eriksson, 2001);
- changes in frequency of intercourse, brought on by physical closeness (Carta et al., 2012) or separation of couples due to, for example, temporary migration or change in profession (Blanc, 2004; Clifford et al., 2010; Lindstrom & Berhanu, 1999; Razzaque, 1988; Simon, 2017);
- voluntary use of birth control in response to the negative experience of the disaster or to perceptions of the probability of a future disaster (Agadjanian & Prata, 2002);
- increases (Cetorelli, 2014) or decreases in the proportion of married people in a population (Clifford et al., 2010; Heuveline & Poch, 2007);
- child mortality (Nobles et al., 2015; Zhu et al., 2013);
- poor reproductive health at conception (Barreca et al., 2018);
- more bonding and time spent between couples during a disaster (Carta et al., 2012; Cohan & Cole, 2002);
- a decrease in access to contraceptives (Behrman & Weitzman, 2016; Clifford et al., 2010);
- altered socioeconomic conditions of households (Agadjanian & Prata, 2002; Fellman & Eriksson, 2001).

The identification of the above processes, as well as the responses to climate disasters, as summarised below, informed the development of the framework presented in Figure 2.1.

Current recent studies based on secondary data sources in many parts of the world have investigated how fertility behaviour (measured as fertility rates) responds to climate variability and related extreme weather events and earthquakes in different settings (Barreca et al., 2018; Sellers & Gray, 2019; Simon, 2017). Some studies revealed that fertility rates increased (Cohan & Cole, 2002; Davis, 2017), while others found that they decreased (Antipova & Curtis, 2015) after hurricanes or severe stormy weather. Fertility rates were reported to have generally declined following droughts and associated famine in Bangladesh, China, Ethiopia, Finland, and Tajikistan (Ashton et al., 1984; Clifford et al., 2010; Coale, 1981; Fellman & Eriksson, 2001; Lindstrom & Berhanu, 1999; Razzaque, 1988). The effects of earthquakes on fertility in different contexts of Haiti, Italy, and Japan varied significantly (Behrman & Weitzman, 2016; Hamamatsu et al., 2014; Lin, 2010; Zhu et al., 2013). Moreover, climate-related disasters have been found to either promote (Behrman & Weitzman, 2016; Carta et al., 2012; Sellers & Gray, 2019) or suppress (Agadjanian & Prata, 2002) people's intention to have children.

Clearly, climate disasters have diverse effects on fertility changes in different countries. While the findings summarised here offer useful insights, there is a lack of empirical research into the ways in which extreme climate events can affect women's fertility and their childbearing intentions. While storms and floods are the most frequently experienced extreme climate events around the world, the limited research into the determinants of fertility associated with such extreme climatic events in developing or underdeveloped contexts is not able to provide us with an adequate understanding.

In population studies or human geography, fertility refers to the output of reproduction rather than just the ability to bear children, which is referred to as fecundity. As a result, a woman's fertility is defined as the number of live births she has (Frank, 2021). The number and outcomes associated with children who are born to women of a particular age group, quantified as children ever born (CEB), present a summary of the birth histories and lifetime fertility experiences of those women until the moment of data collection. This number includes all babies born by women who are alive or dead at the time of data collection. If census and survey data are insufficient or unavailable, data on children ever born to consecutive age groups of women give information on the overall tendency to have children, which can be used to forecast reproductive behaviour in an area (United Nations, 2013). Fertility indicators can also include the desired number of children, as reported by the woman, and the number of infants that survive. A woman's desired fertility or ideal fertility at any particular period is the overall fertility she wants to have throughout her lifetime. The number of living children refers to the number of surviving offspring of mothers at the time of data collection.

Intentions are immediate antecedents of the corresponding behaviour (Fishbein & Ajzen, 2010). Fertility intentions relate to the plan to have or not have a child, based on the current circumstances of the individuals making the plan (Vignoli & Rinesi, 2014). Demographers focus on fertility intentions for two reasons (Philipov, 2011). Firstly, doing so helps to understand fertility behaviour and fertility rates from the macro-level perspective; secondly, it helps to understand the determinants that drive the realisation and frustration of such intentions at the micro-level. This study focused on fertility intentions, which are considered core to the discussion of fertility rates and family planning. Scholars who follow the theory of planned behaviour (TPB), a psychological theory that sees a person's intentions as the strongest predictor of their behaviour, typically ask about fertility intentions within a timeframe of three years (e.g., "Do you intend to have a child in the next 3 years?") (Mencarini et al., 2015).

It is important to distinguish fertility intentions from fertility preferences. Fertility intentions are related to the planning or action to conceive; fertility preferences denote the feelings or desires to have children (Thomson, 1997). Philipov (2011, p. 40) differentiated the concept of desire from intention, explaining that "a desire is assumed to be independent of the current circumstances while an intention should have been formed with some awareness of the effect of their presence". Despite these differences, both concepts are helpful in predicting reproductive behaviours and completed fertility (Thomson, 1997; Westoff & Ryder, 1977). That said, in this study, fertility intentions are of greater interest than fertility preferences and its exploration of how the present or anticipated future circumstances of people-including their experiences of climate-related disasters, their perceptions of extreme climate events, the vulnerability of their households-influence their fertility and intentions to have another child in the future.

2.5.1 Experiences, perception of extreme climate events, and fertility decisions

Extreme climate events can affect several determinants that influence people to have more children. One such determinant is the person's experience of the event and how they perceive extreme climate events will affect them in the future. Dzialek (2013) noted that people are becoming more and more concerned with climatic events that create an immediate and direct impact and involve countless casualties in a short period of time and space. He defines the perception of climatic hazards (or extremes) as "involv[ing] intuitive judgments, beliefs, and attitudes adopted by individuals and groups of people about the likelihood of occurrence and course and mechanisms of development of such phenomena" (Dzialek, 2013, p. 756).

Wachinger and Renn (2010) suggest that, when experience shapes one's perception of extreme climate events, familiarity with a climatic event such as a cyclone can facilitate an increased understanding of the risk and danger associated with such an event in the future. Smith (2001) suggested that perceptions developed in response to an experience of an extreme event could, in fact, be categorised, from the viewpoint of those perceiving the hazards, into three categories: (1) determinate perception, (2) dissonant perception, and (3) probabilistic perception. Determinate perception is held by those who, having experienced an extreme climate event, aim to identify the pattern of such events (e.g., the frequency of such extreme climate events in the last ten years). People with this perception also try to rationalise the occurrence and prepare themselves for the likelihood of another.

The second category, *dissonant perception*, is similar to the first only in that people in both categories have experienced an extreme climate event. The significant difference is that the people of the first group rationalise the occurrence while the latter group denies the occurrence, primarily because they perceive that the incidence was exceptional and less likely to recur in their lifetime. Such behaviour serves as a sort of psychological adaptation strategy (Bell et al., 2005). Often, those who live in high-risk environments (such as those found in Bangladesh, where people experience the frequent, unpredictable, and rapid occurrence of cyclones or flash floods) are more concerned with their day-to-day affairs than they are with climatic events that go out of their control (e.g., cyclones or floods) (Tobin & Burrel, 1997).

The third set of probabilistic perception is held by people who recognise the frequent occurrence and the probability of extreme climate events in their lifetimes. People of this group perceive that government and non-government agencies have the responsibility for dealing with extreme climate events; these are not for them to deal with. People in this category perceive the extreme climate event as an act of God and do not take preventive measures.

Perceptions and experiences of extreme climate events have been shown to influence the adaptive behaviours of individuals (Dillon et al., 2011; Silver & Andrey, 2014). Differences in behaviour have been observed between people who had experienced extreme climate events than those who had not. For example, flood victims in the UK have been found to be more concerned about changes in climate factors than non-victims (Spence et al., 2011; Whitmarsh, 2008).

Though perceptions and experiences of extreme climate events are often used interchangeably and seen to directly affect behaviour, some studies (e.g., Battaglini et al., 2009; Silver & Andrey, 2014) have used them separately. A study on high school students of southern China revealed that experience influenced perceptions first and indirectly affected adaptive behaviours (Deng et al., 2017). Spence et al. (2011) found that experiences of flooding had a direct effect on behaviour to decrease energy use, and that climate change perceptions had an indirect effect on behaviour such as increased energy use. It has also been argued that a previous experience of an extreme event changes the person's perceptions about the frequency and magnitude of the future event (Brown et al., 2018).

Delineating the complicated relationship between extreme climate events and fertility behaviour is an important research topic for those working in the fields of the environment (or climate change) and population dynamics (Mustelin et al., 2010; Xiao & Hong, 2010). It is essential to take fertility rates, among other demographic determinants (e.g., the growth rate of population, encroachment of populations, and urbanisation), into account in areas which are susceptible to climate variation and extreme weather events in order to understand vulnerability to climate extremes at the household level and to inform approaches to adaptation and mitigation (Jiang & Hardee, 2011).

This study investigates the effects of both the perception and experience of extreme climate events on fertility behaviour, because people's decisions are influenced by their subjective experience of extreme climate events and their behaviour is often a product of their perceptions of such events (Dzialek, 2013). The study of human perceptions of extreme climate events can be of significant benefit to disaster risk reduction and climate change mitigation policies.

It is important to take into consideration the fact that the views of extreme climate events may vary from one community to another. As the vulnerability to climate change of a cyclone-prone community differs from that of a drought-prone area (Xenarios et al., 2016), it has been assumed that the perception of an extreme climate event will depend on whether the perceiver lives in a community vulnerable to a flood or a cyclone. Rural populations have been found to better understand extreme climate events than city-dwellers, arguably because they live very close to nature (Dzialek, 2013). According to Bell et al. (2005), rural populations consider extreme climate events a threat because they hamper their livelihoods and subsequent income.

2.5.2 Nexus between households' vulnerability, the impact of extreme climate events, and fertility intentions

The frequency and intensity of extreme climate events have increased over the past few decades in many parts of the world (EM-DAT, 2022). The IPCC sixth assessment report states that these unprecedented weather events and climatic extremes are human-induced (Seneviratne et al., 2021). Such extreme climate events have adverse effects on aspects of human life, including agricultural production, livelihood, health, and economic conditions (IPCC, 2014), through which climatic extremes can affect demographic processes, including fertility, migration, and mortality and, in turn the size, spread, and structure of future populations (Muttarak, 2021).

Effect of extreme climate events on the human population is unequal and varies at individual, family, and community levels. Therefore, the ability for individuals to cope with and communities to take adaptation measures to address these events varies significantly, depending on the characteristics of the population. Differences in exposure to climatic hazards (e.g., cyclones, floods, drought), physiological sensitivity, and economic, social, and psychological determinants, as well as demographically distinct vulnerabilities, affect risk perceptions and responsiveness (Muttarak et al., 2016). In short, the vulnerability of a community to extreme climate events depends not only on the type of climatic hazard to be faced but also on the demographic characteristics of that community. Thus, an understanding of population formation is very relevant to the assessment of both the vulnerability of a society and its ability to adapt to extreme climate events (Lutz & Muttarak, 2017).

According to the vulnerability framework (Pandey & Jha, 2012), the three dimensions of exposure, sensitivity, and adaptive capacity determine a household's vulnerability to climate-related extremes. Critical components or variables of the dimensions mentioned above can also critically shape women's fertility intentions, including, in particular, environmental or extreme pressures (exposure), health and food (sensitivity), and the livelihood, socio-demographic status, and social networks of households (capacity).

2.6 Theoretical approaches to the interpretation of fertility changes occurring in response to extreme climate events

Demographers typically rely on many determinants associated with demographic, economic, socio-cultural, and policy contexts to model fertility behaviour and trends for countries with different demographic and economic transitions. Given the increasing frequencies and intensities of climate change and extreme climate events that are affecting every aspect of human settlement, it is becoming increasingly difficult and uncertain to predict human behaviour, including but not limited to their fertility behaviour, based on conventional demographic and economic theories of fertility changes. The complex and multifaceted effects of extreme climate events on fertility have been little explored, and this has an impact on the relevance and appropriacy of government policies around foreign aid, disaster insurance, and the environment (Lin, 2010). As reported above, the scant existing research has shown that fertility can increase or decrease after an extreme climate event. There has also been some attempt to identify the determinants that facilitate or hinder reproductive activities and drive changes in reproductive outcomes.

A popular theory in fertility intention research is the theory of planned behaviour (TPB). This theory focuses mainly on the nexus between attitudes and behaviour (Ajzen, 1991; Ajzen, 2005; Fishbein & Ajzen, 2010). According to the TPB perspective taken by Azen and Klobas (2013), three primary antecedents drive a person's intention to have a (another) child: attitudes, subjective norms, and perceived behavioural control. These researchers argue that these antecedents are the most important determinants of fertility intentions, and, while conceptually different, are interrelated. *Attitudes* reflect the personal assessment of whether having a (another) child will bear positive or negative consequences. The *subjective norms* are the expectations of a specific group or the social pressure which influence a couple to have another child. Finally, *perceived behavioural control* involves the determinants that may promote or hinder reproductive activity.

From the reproduction disruption perspective, research suggests that the loss and damage, particularly to agricultural and non-agricultural production, livelihood, and assets, as the result of an extreme climate event may increase the vulnerability of the households such that a couple may revise their decisions to have children (Casey et al., 2019; Sellers & Gray, 2019). Moreover, the extreme climate event itself may result in the displacement or death of a partner and/or physical harm including miscarriage that can hinder reproductive activity (Barreca et al., 2018; Carrico & Donato, 2019; Roeckert & Kraehnert, 2021). These disruptions may influence the couples/women to revise any short-term reproductive planning. The disruption to fertility that occurs when a couple delays the birth of their next child is called *tempo-effect* (Bongaarts & Feeney, 1998).

On the other hand, extreme climate events have also been found to promote reproductive activity (Cohan & Cole, 2002; Carta et al., 2012; Evans et al., 2020). When extreme climate events such as floods or cyclones occur, people have to stay in place for extended periods of time during which ordinary life is also disrupted. This is especially true in flood-prone areas: people cannot move without a boat and so stay at home. When a climatic event causes couples to hunker down in a place for extended periods, this event itself can lead to higher coital frequency (Cohan & Cole, 2002). For example, Cohan and Cole (2002) observed increased birth rates in areas affected by Hurricane Hugo in South Carolina in 1989 and highlighted that the stress associated with the experience had reportedly caused people to forget to use contraception. Evans et al. (2010) concur that extreme climate events can impede access to contraceptives during and after they occur. According to the attachment theory of psychology, during periods of elevated stress, couples seek emotional support and often tend to be physically intimate with their partner (Zeifman & Hazan, 2008). This closeness has been found to increase coital frequency between couples, and, in turn, fertility (Carta et al., 2012).

Extreme climate events can cause the death of children, either directly or indirectly, and this has been found to drive higher rates of fertility. A crosssectional study in India, Pakistan, and Turkey found that women who had experienced the loss of a child due to a disaster had more children afterwards and wanted to have one-for-one replacement (Finlay, 2009). Even a high risk of infant mortality can drive rises in fertility, as parents aim to have a certain number of surviving children (Lutz et al., 2006). Finlay (2009) concluded that people living in areas vulnerable to frequent climatic extremes with a high risk of child mortality, and therefore facing the probability of losing a child, prefer to have more children; she referred to this approach to fertility as an *insurance mechanism*. Finlay also described the *replacement effect* on fertility: a child's death influences the couple to have another child to replace the one who was lost. Yeatman et al. (2013) determined that young Malawian women were likely to want more children as a safeguard (insurance mechanism) against child deaths that could occur in the future. Therefore, in response to unanticipated extreme climate events, fertility is expected to increase, either as an insurance mechanism or a replacement effect.

2.7 Conclusion

Our world regularly witnesses climatic, natural, human-made, and biological disasters which have far reaching consequences for human dynamics, health, and well-being. Some outcomes are irreversible and unevenly distributed across different countries and population subgroups. Poorer populations specifically and the least-developed and developing countries in general bear the brunt of the adverse effects of disasters, with critical effects on global mortality, migration, and fertility. The latter aspect of human dynamics has not received much attention from scholars focused on human geography and social demography. The review of the literature presented in this chapter identifies a number of critical determinants that can influence fertility dynamics and potentially increase or decrease fertility rates. However, the effects of disasters on fertility rates are not straightforward and uniform. Existing theories argue that one disaster can promote (or increase) these rates, while another of even the same type can disrupt (decrease) them. Moreover, the critical determinants can have varying direct and indirect effects on both fertility and the intention to have additional children, depending on the type of extreme climate event. The next chapter describes the study area and approaches taken to identify, specifically, the effects of cyclones and floods on the determinants of fertility in Bangladesh.

Part of Chapter 3 has been published in the details below.

Statement of Authorship

Title of Paper	Assessing and mapping spatial variations in climate change and climatic hazards in Bangladesh
Publication Status	☐ √ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	**Ahmed, K. J.**, & Tan, Y. (2021). *Assessing and mapping spatial variations in climate change and climatic hazards in Bangladesh*. In Alam, G. M. M., Erdiaw-Kwasie, M. O., Nagy, G. J., Filho, W. L. (Eds), Vulnerability and resilience in the global south: Human adaptations for sustainable futures (pp. 465-486). Springer, Netherlands. https://doi.org/10.1007/978-3-030-77259-8_24

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Contribution to the Paper	Conceived and designed the analysis, collected data, reviewed literature, performed the analysis, interpreted data, wrote the manuscript, and acted as corresponding author.		
Overall percentage (%)	60%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	7/4/2022

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Please cut and paste additional co-author panels here as required.

Chapter 3 Methodology

3.1 Introduction

This chapter describes the research methods undertaken to obtain and analyse primary data collected during fieldwork conducted in two rural areas in Bangladesh from July 2019 to February 2020. The chapter begins with the assessment of geographical variations of cyclones and floods in Bangladesh based on historical data, which was carried out to identify two villages for study, one prone to cyclones and another to floods. Then, the use of a mixed methods approach in the context of research on extreme climate events and fertility is discussed. Afterwards, three distinguished phases of data collection procedures are explained. The first phase of data collection included key informant interviews with experts and focus group discussions with male residents in the selected villages. The following two phases targeted married women for household surveys and in-depth interviews. The last section describes the analysis techniques for quantitative and qualitative data that have been obtained from the fieldwork.

3.2 Study areas: selection of districts vulnerable to cyclones and floods

The goal of this section is to describe the geographical variations among administrative districts of Bangladesh that are severely hit by cyclones and floods, and the methodology used to evaluate these districts to determine areas for research.

3.2.1 Assessing spatial variations in cyclones and floods in Bangladesh

Extreme climate events result in disastrous damage and loss, affecting human settlements and the broader environment. Understanding climatic extremes is an important practical outcome of environmental climatology, and it is imperative that those managing disaster risk are able to determine which areas are likely to experience catastrophic climatic extremes (Cutter et al., 2000). The goal of this section is to report the way existing climate and geographical data were examined to assess spatial variations in the extreme climate events of cyclones and floods in Bangladesh.

To explore spatial variations in climatic hazards in the 64 districts of Bangladesh, historical disaster records from the years 1900 to 2018 were collected from the Emergency Events Database (EM–DAT), the international disasters database administered by the Centre for Research on the Epidemiology of Disasters (CRED). EM–DAT classifies as a *disaster* any event that causes one or more of the following: a) ten or more human deaths, b) substantial effects on the lives of 100 or more people, c) a declared state of emergency, or d) a call for international assistance. Notably, this classification and recording regime excludes some smaller-scale events that also have devastating impacts on local communities. Disaster records for all Bangladesh districts were comprehensively sorted, such that if a disaster affected more than one district, it was counted separately for each. For example, on 29 to 30 July, 2015, one flood event, which affected Cox's Bazar, Chattogram, Noakhali, Feni, Bandarban, Patuakhali, Bhola, and Barguna, occasioned eight distinct recordings. Only floods and cyclones were considered in this review of the data, because these most frequently occur in Bangladesh and globally. Other events such as droughts, earthquakes, epidemics, extreme temperature events, and landslides were excluded from this analysis, since they occur too infrequently in Bangladesh to determine spatial variation across administrative districts.

District-wise hazard scores for both floods and cyclones were computed first. The hazard scores were determined by calculating overall district hazard factors and also weighting factors assigned to individual hazards. Hazard factors for a given district are derivable from the district's historical database, which provides associated intensity scales or frequencies of occurrence. Initial hazard factors were classified into 5 Likert scale response categories, with 1 meaning not hazardous and 5 extremely hazardous. Hazard factors were also dependent on the occurrence (or count) of the extreme events.

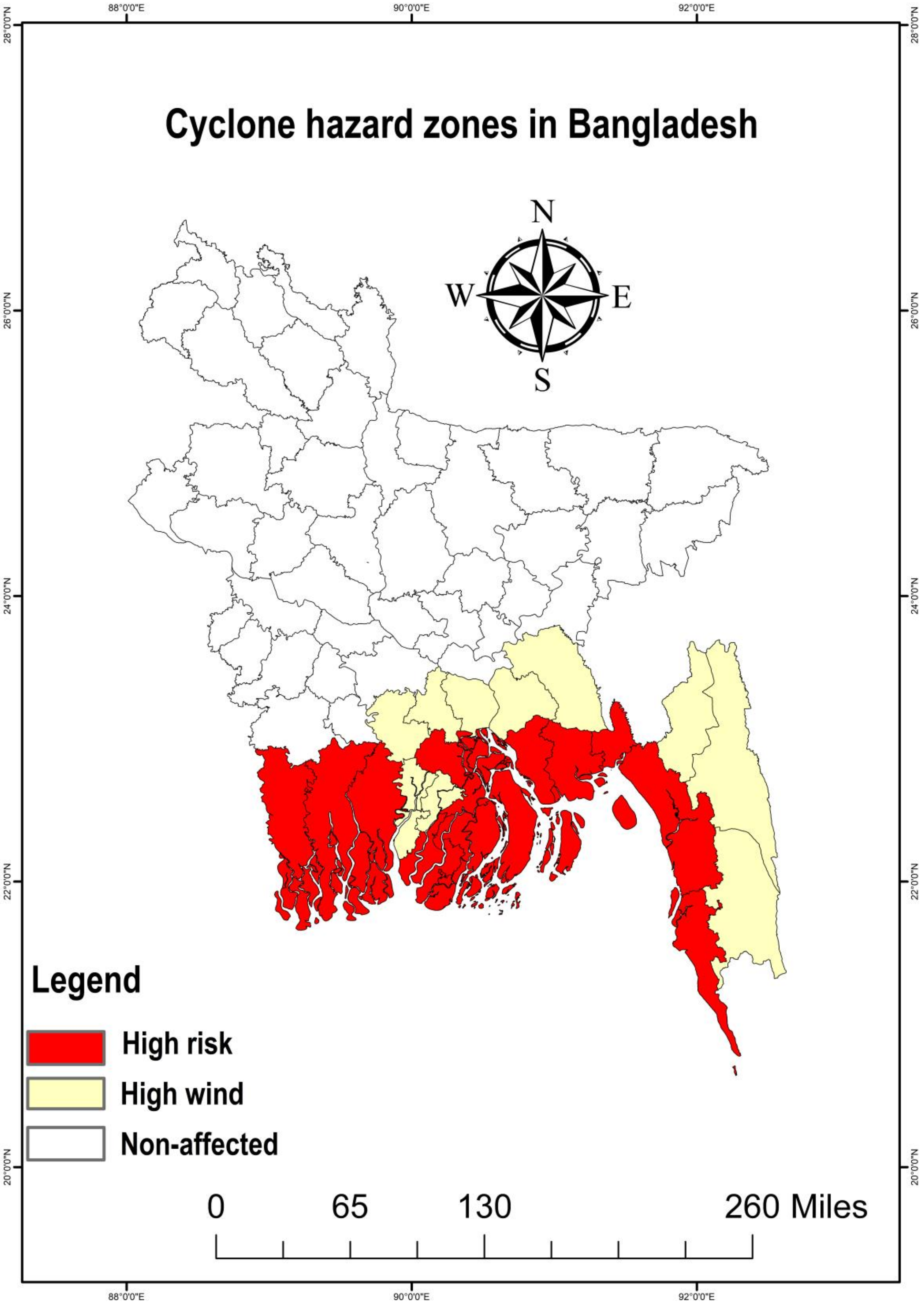
Once district-wide hazard scores had been developed, based upon the above hazard factors, weighting factors were allocated to both floods and cyclones, allowing for the occurrence of unique extreme climate events in different districts. The allocation of weighting factors was achieved by a proportional priority scoring system (with higher hazard-prone areas receiving higher scores) for which the baseline was set at a score of 1.0 for non-disaster locations, and an increase in the number of occurrences added 0.1.

Information on cyclone zoning and corresponding hazard factors was drawn from the published study by Barua et al. (2016) that classified the districts of Bangladesh as part of their development of a cyclone intensity scale. These researchers grouped all 64 districts into three cyclone zones: non-affected, high-wind, and high-risk. Furthermore, hazard factors were assigned from *lowest* for the non-affected zone to *highest* for the high-risk zone (see *Table C1, Appendix C*). A majority of districts (42 out of 64) are not vulnerable to cyclones; ten districts lie within the high-wind zone, and 12 districts are assigned to the high risk zone. These high-risk districts (Barguna, Barishal, Bhola, Patuakhali, Chattogram, Cox's Bazar, Feni, Lakshmipur, Noakhali, Bagerhat, Khulna, and Satkhira) are all located in the coastal belt.

Weighting factors were defined by corresponding frequency classes of cyclone data, based on the EM–DAT database. The district with the highest frequency of cyclone events is Chattogram, with 32. Frequencies were grouped using an equal interval method, in which the interval is 4. Accordingly, the highest weighting factor assignable is 1.8, using the frequency of cyclones and their corresponding weighting factors (see *Table C2, Appendix C*). District-wise cyclone hazard factors and weighting factors were assigned considering corresponding cyclone zones and frequencies.

This hazard analysis increased our understanding of spatial variations in climatic hazards across Bangladesh. Figure 3.1 presents the results of the categorisation of districts according to hazard zones. Of particular interest to this study are the twelve districts that are grouped as highly vulnerable to cyclones, ten of which (the exceptions are Chattogram and Cox's Bazar) were additionally identified as very highly vulnerable due to their agricultural, climatic, occupational, demographic, and geographical salience (Islam et al., 2013). A more recent study by Hossain et al. (2019b) similarly judged ten of these twelve districts (the exceptions being Patuakhali and Lakshmipur) to be very high-risk zones for cyclones. For interested readers, a detailed list of cyclone hazard districts is presented in the Appendix (see *Table C3, Appendix C*).

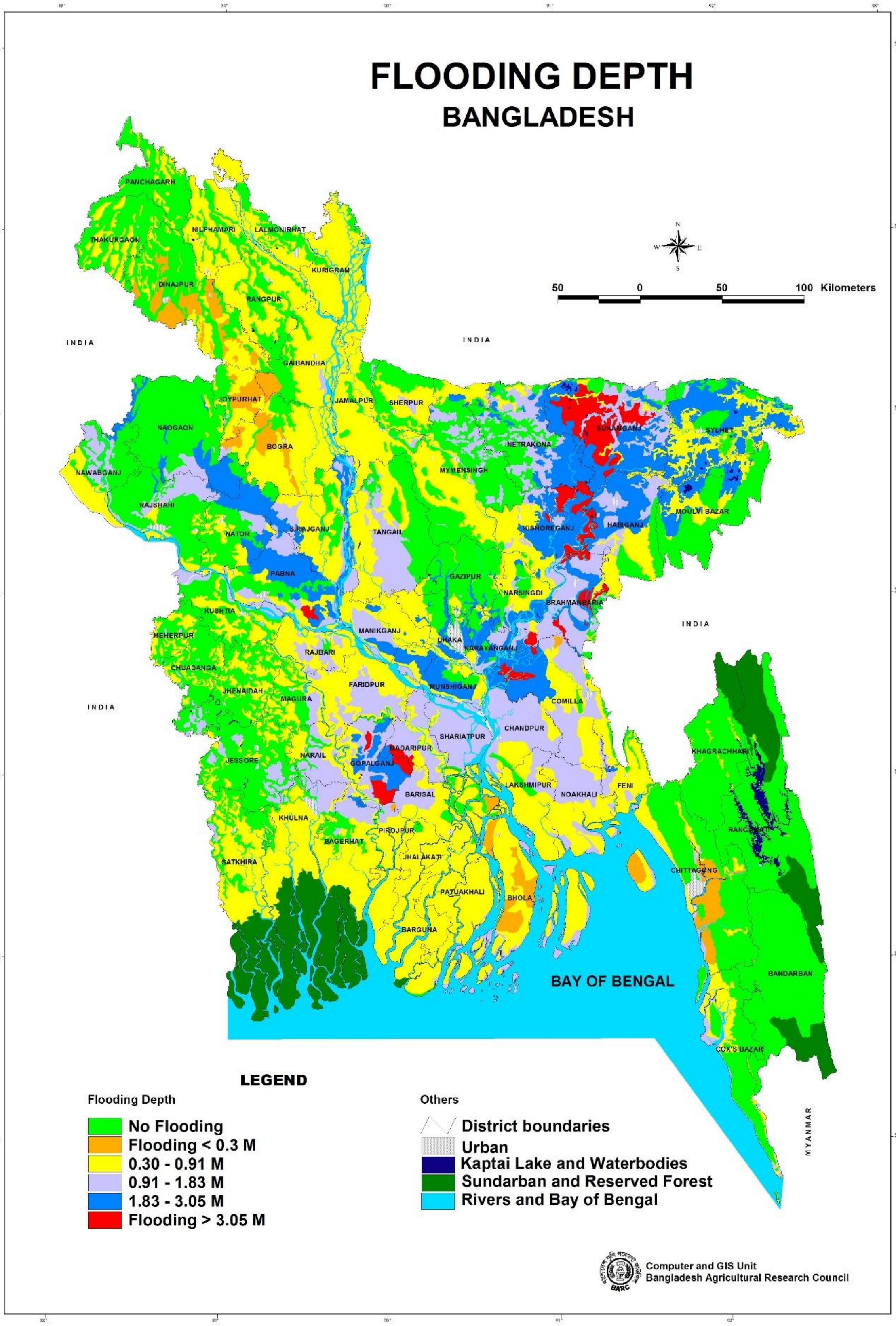
Figure 3.1 Districts in Bangladesh corresponding to cyclone hazard zones based on hazard scores.



Source: Author's own using ArcMap version 10.6.1.

To identify flooding zones and intensity (measured by recorded flood depth), this research used the map, as shown in Figure 3.2, developed by the Computer and GIS Unit of the Bangladesh Agricultural Research Council (BARC) (www.barc.gov.bd). Each of the 64 districts delineated in this map is allocated to one of six flooding zones in terms of flood depth: *no flooding*, <0.30 m (*normal flooding*), 0.30–0.91 m (*moderate flooding*), 0.91–1.83 m (*moderately high flooding*), 1.83–3.05 m (*high flooding*), and >3.05 m (*extreme flooding*) (see *Table C4, Appendix C*). This classification is mostly consistent with the flood zoning suggested by Barua et al. (2016).

Figure 3.2 Distribution of flooding by administrative districts in Bangladesh.



Source: Bangladesh Agricultural Research Council.
[http://maps.barcapps.gov.bd/images/Edaphic/flooding_depth.jpg]

The weighting factors addressed variations in of flood intensity, by creating six Likert scale response categories to develop a *hazard index* that corresponds with the flooding depth data. The "no flooding" zone was assigned a hazard index of 1; 2 for "normal" and "moderate" flooding; 3 for "moderately high" and "high" flooding; and 5 for "extreme" flooding (Table 3.1). The weighting factors for the respective frequency classes were then specified. Here 6 was attributed to the highest level of flooding events, so 1.6 is the most significant weighting factor (see *Table C5, Appendix C*).

Table 3.1 Flood zones and their corresponding hazard factors.

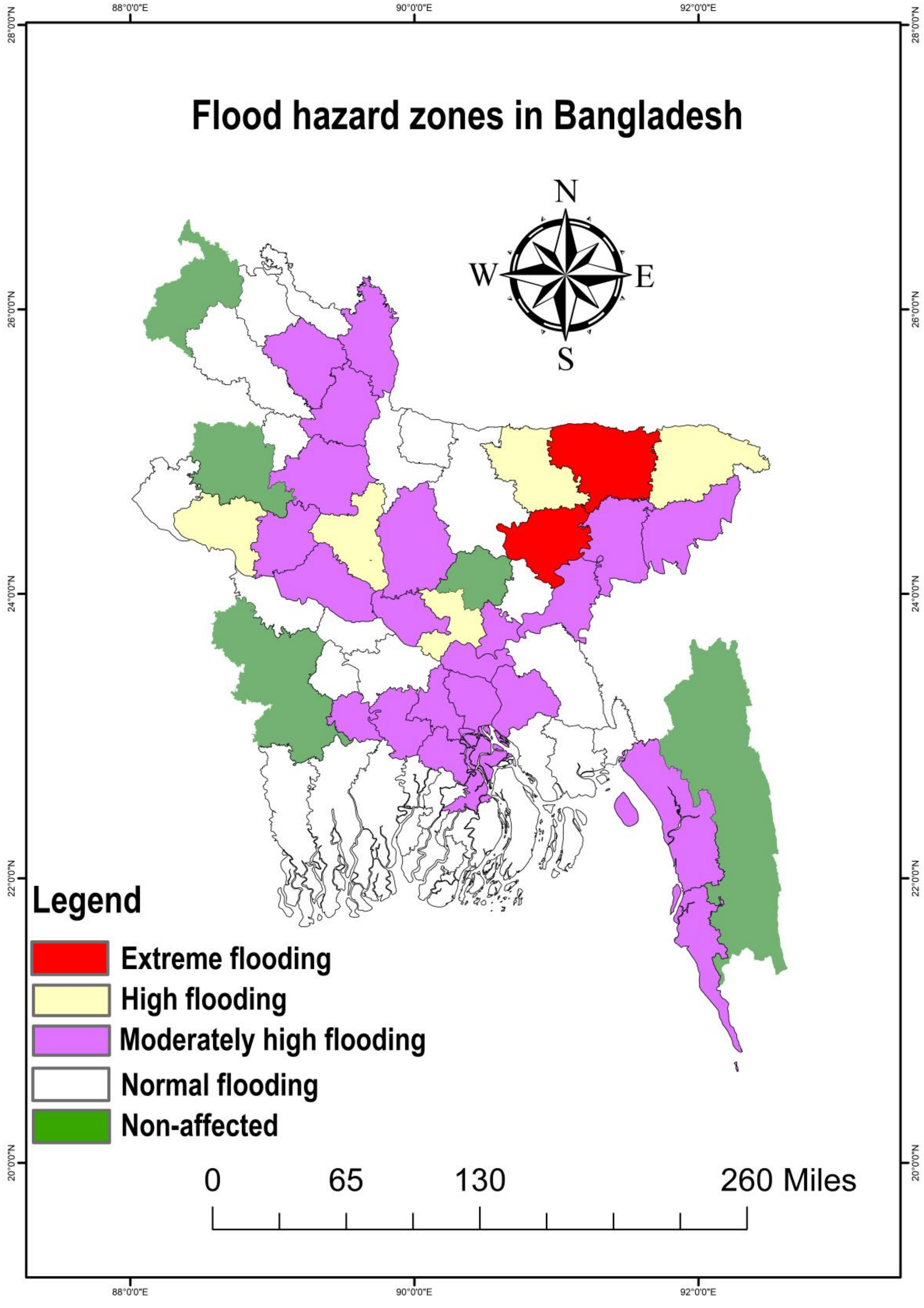
Flood zones	Number of districts	Intensity	Hazard factor
No flooding	11	1	1
Normal (depth <0.30 m)	2	2	2
Moderate (depth 0.30–0.91 m)	30	3	2
Moderately high (depth 0.91–1.83 m)	10	4	3
High (depth 1.83–3.05 m)	9	5	3
Extreme (depth >3.05 m)	2	6	5

Source: Author's estimation using the flood distribution map as presented in Figure 3.2.

Considering the appropriate flood zone and frequencies of floods, district-wise hazards and weighting factors were then allocated. The flood hazard scores for all districts in Bangladesh were determined, by combining all relevant flood hazard and weighting factors (see *Table C6, Appendix C*).

The findings show that two districts in the northeast region, Kishoreganj and Sunamganj, are extremely prone to floods, as shown in Figure 3.3. Haque et al. (2021) also revealed that significant areas within these two districts are highly susceptible to flash flood hazards. As shown in Figure 3.3, five districts are classified as high-flooding: in the centre (Dhaka), the west (Rajshahi and Sirajganj), and the northeast (Netrokona and Sylhet) of the country. Except for Gopalganj, these regions were classified in previous research based on water-level data as severe flooding zones (Barua et al., 2016). Again, for interested readers, a detailed list of flood hazard districts in presented in the Appendix (see *Table C7, Appendix C*).

Figure 3.3 Districts in Bangladesh corresponding to flood hazard zones based on hazard scores.



Source: Author's own using ArcMap version 10.6.1.

The findings show that two districts in the north–east region (Kishoreganj and Sunamganj) are extremely prone to floods, as shown in Figure 3.3. Haque et al. (2021) also revealed that significant areas from the two districts are highly susceptible to flash flood hazards. As shown in Figure 3.3, five districts are classified as high–flooding: in the centre (Dhaka), the west (Rajshahi and Sirajganj), and the north–east (Netrokona and Sylhet). Except for Gopalganj, these regions were in previous research classified as severe flooding zones based on water–level data (Barua et al., 2016). For interested readers, a detailed list of flood hazard districts in presented in the Appendix (see *Table C7, Appendix C*).

Based on the literature and statistics of loss and damage from recent cyclones and floods in 2019 and in consultation with climate change experts in Bangladesh, two districts of Bangladesh were selected for this study: *Satkhira*, of the high-cyclone-risk areas, and *Sunamganj*, of the extreme flood–prone areas. During cyclone Aila on 25 May, 2009, the 12 worst affected districts were *Satkhira*, Khulna, Bagerhat, Pirojpur, Barisal, Patuakhali, Bhola, Laksmipur, Noakhali, Feni, Chattogram, and Cox's Bazar (Roy et al., 2009). Of these districts, *Satkhira* was the worst affected, with 59 deaths out of the 190 experienced across all the affected districts (Gupta, 2009). *Sunamganj* was one of the worst affected districts by floods in 2016, 2017, 2019, and 2020 (BDRCS, 2019; Chakraborty et al., 2021; Haque et al., 2021; NIRAPAD, 2016, 2017).

3.2.2 Selection of corresponding subdistricts, unions, and villages

Sunamganj district is in the northeast of Bangladesh and Satkhira district is located in the southwest. Table 3.2 presents the socio-demographic and health care utilisation in these two districts, based on data collected by NIPORT et al. (2019). Since both districts are geographically as well as socio-culturally distinct, there are differences in their socio-demographic and other health indicators. The socio-demographic indicators suggest that Sunamganj has a higher poverty rate (48.8%) and a lower number of educated women (25.9%) than those in Satkhira (14% poverty and 47.9% schooling). More than half of the younger women aged 15 to 19 years in Satkhira were married at the time the data were collected, and they had a low number of children. In contrast, approximately one-third of the younger women were married in Sunamganj and had more than three children. Women in Satkhira were more likely to access contraceptives (64%) than those in Sunamganj (54.7%). Women in Satkhira were also more likely (almost 2 times) to have the deliveries of their babies attended by a skilled birth attendant and at a health facility than their counterparts in Sunamganj. Child mortality indicators suggest that women in Sunamganj were more likely (almost 2 times) to witness the death of child compared to their counterparts in Satkhira. While these underlying differences in socio-demographic and health indicators could explain the variations in fertility rates between the selected districts, the fertility effects of extreme climate events that frequently affect the populations of these two districts and induce loss and damage are undeniable, and merit further investigation.

Table 3.2 Differences in socio–economic, fertility, health, and child mortality in Satkhira (*Cyclones*) and Sunamganj (*Floods*) districts.

Indicators	*Satkhira*	*Sunamganj*
Socio–economic (%)		
Households in poverty	14	48.8
Females (aged 15-49) with secondary or higher education	47.9	25.9
Marriage and fertility (%)		
Female adolescents (aged 15-19) currently married	52.4	31.6
Total fertility rate (TFR)	1.79	3.64
CPR for any method	64	54.7
CPR for a modern method	56.9	47.1
Maternal health (%)		
Deliveries attended by a skilled birth attendant (SBA)	56	28.2
Deliveries at a health facility	51.7	26.3
Childhood mortality (%)		
Neonatal mortality	28	45
Post neonatal mortality	6	16
Infant mortality	33	60
Child mortality	6	12
Under-five mortality	39	72

Note: Two villages have been selected from the districts: Chadnimukha from Satkhira and Lamagaon from Sunamganj.
Data source: NIPORT et al. 2019.

After the two districts had been selected for study, a sub-district (*upazila)* from each district was also selected, based on the available literature on recent extreme climate events that had occurred in 2019 in the districts. *Shyamnagar*, a sub-district of Satkhira, was found to have been severely affected by Cyclone Aila in 2009, a finding confirmed by numerous studies and government reports that identified this sub-district as very highly vulnerable compared with other sub-districts (Garai, 2014; Hossain et al., 2018; Jakariya et al., 2016; Kumar et al., 2010;

Mallick et al., 2011; Martin et al., 2014; Tajrin & Hossain, 2017). *Tahirpur* was the sub-district of Sunamganj deemed highly vulnerable to floods (Bhowmik et al., 2021; Raihan & Hossain, 2021).

During the fieldwork, consultation with experts was undertaken to identify most vulnerable areas. The researcher met first with the Upazila Nirbahi Officers (UNOs) of Shyamnagar and Tahirpur to find out the *union* (the layer of government below *upazila*) within each of the two sub-districts that was most vulnerable to recent extreme climate events in 2019. It should be noted that a UNO is a chief executive of an upazila whose leading role is to coordinate with a wide range of different departments[3] of the central government at the upazila level. UNOs also serve as vice–chairs of their local Upazila Disaster Management Committees (UzDMC), and in these roles, participate and witness the activities of disaster management. UNOs know a great deal about the socio-economic and demographic conditions as well as the climatic hazards of their areas. Following the consultation with the local UNO, the Union Chairman from that area, who serves as Administrative Chief of a union and the Chairperson of the Union Disaster Management Committee (UDMC)[4], was consulted in order to identify the most vulnerable village from within the designated union as well as to inform them about the research.

Ultimately, two unions[5] were selected: *Gabura* of Shyamnagar Upazila[6] and *Sreepur South* of Tahirpur Upazila. A number of studies had previously selected Gabura Union as a cyclone-affected study area (Garai, 2014; Mallick et al., 2011; Martin et al., 2014). *Sreepur South* Union had been selected as a severe flood-affected study area by Haq and Ahmed (2019). Table 3.3 contrasts the characteristics in 2019 and 2020 the selected unions, as reported by the Union

[3] These departments include Upazila Health and Family Planning, Agriculture, Fisheries, Livestock, Engineering, Social Services, Family Planning, Project Implementation, Women's Affairs, Cooperatives, Rural Development, Public Health and Engineering, Food, Land, Statistics, Youth and Development and Police Station (*thana*). In addition to these the departments include some project-based offices like *Palli Jibikayan*, Upazila Resource Centre. The Upazila Election Office is also included as a department.

[4] The UDMC consists of 36 members. The chairperson of the Committee can co-opt a maximum of three additional members and form groups and sub-groups depending on the local situation and special circumstances. The UDMC has been given the mandate to act as the rural disaster management entity and is supposed to play a key role in disaster preparedness, mitigation, emergency response, and post-disaster rehabilitation.

[5] *Unions* are the smallest rural administrative and local government units and represent the lowest tier of local government.

[6] The second-lowest tier of regional administration in Bangladesh, the upazila, is administratively similar to a district and plays the most crucial role. The core functions of an upazila involve the coordination of the development and administrative activities at the division, district, and upazila levels, the maintenance of general and revenue administration, and the performance of magistracy.

Parishads of Gabura and Sreepur South. When comparing the two unions, it is necessary to keep in mind that, in Bangladesh, each union is made up of nine villages. The total area (m^2) of Sreepur South union (47.12 m^2) is larger than Gabura (33 m^2), but the latter has a higher population, because the villages in Sreepur South union are widely scattered and most of the area is covered by wetlands (Table 3.3). At the time data were collected, there were 18 NGOs working in the Gabura union; the number operating in Sreepur South was not reported in the administrative documents of that sub-district. The key informant interview with an administrative official (e.g., Upazila Nirbahi Officer) and an expert of an international NGO (The World Vision) confirmed that three NGOs were working in the Sreepur South union: a microfinance institution named Bangladesh Rural Advancement Committee (BRAC), *Ektee Bari, Ektee Khamar* (One House, One Farm) and *Shouhardyo*. The *Shouhardyo* project supports child health and nutrition.

Table 3.3 Comparison of cyclone- and flood-hit unions selected for this study.

Descriptions	***Gabura union***	***Sreepur South union***
Total area (m^2)	33	47.12
Number of villages	15	42
Total households	8321	4748
Total population	43262	26927
Number of NGOs	18	3
Literacy rate (%)	43	29
Number of community clinics	4	2
Cyclone/flood shelters cum primary schools	9	5
Union Health and Family Welfare Centre	1	/
Natural hazards	Cyclonic storms, riverbank erosion, erratic rainfall, and salinity	Flash floods, rainwater floods, hailstorms, storms, and thunderstorms
Major livelihood options	Catching fish and crabs, agricultural and non–agricultural wage labour	Agriculture and fishing

Note: One village has been selected from each union for this research: **Chadnimukha** is a cyclone-hit village from Gabura union and **Lamagaon** is a flood-hit village from Sreepur South union.
Source: Union Parishads of Gabura and Sreepur South, 2019–2020.

Overall, according to this information for the years 2019 and 2020, the village of Gabura enjoys a number of advantages, by comparison with the village of Sreepur South. In Gabura, the literacy rate was comparatively higher in Gabura, as was the number of community clinics serving this village: four, which was the double the number serving Sreepur South. Moreover, Gabura had more shelters than Sreepur South available for use during disasters. The most common hazards in Gabura were cyclonic storms, erratic rainfall, salinity, and riverbank erosion. In contrast, flash floods, hailstorms, storms, and thunderstorms endangered Sreepur South. The primary economic activities of Gabura dwellers were collecting forest resources (e.g. log collecting, honey harvesting), crab fattening, shrimp farming, agricultural labouring, and catching fish from the river; in Sreepur South, people farmed in the dry season (December–April) and relied on fishing in the wet season (June–October).

Ultimately, one village[7] of each union was selected based on the information provided by the Upazila Nirbahi Officer (UNO) and the Union Chairman of each area: **Chadnimukha** of Gabura and **Lamagaon** of Sreepur South.

3.3 Research approach: Philosophical and fieldwork viewpoints

3.3.1 Philosophical standpoint

Philosophically, this research takes a pragmatic approach. Pragmatism is a worldview that emphasises using all possible approaches to understand the research subject (Tashakkori & Teddlie, 1998). A pragmatic approach is not confined to a particular philosophy: data can be collected in a wide variety of ways. This approach aligns well with mixed methods research, through which both quantitative and qualitative assumptions are addressed. Creswell (2018, p. 59) states that “for the mixed methods researcher, pragmatism opens the door to multiple methods, different worldviews, and different assumptions, as well as a different form of data collection and analysis”.

3.3.2 Mixed–method strategies: Fieldwork approach

Collecting diverse types of information provides the researcher with an opportunity to understand a specific research problem more comprehensively than they might had they relied on either qualitative or quantitative data alone (Creswell & Clark, 2017). Creswell and Creswell (2018) categorised mixed methods research into three types: sequential, concurrent, and

[7] In Bangladesh, a village is the smallest territorial and social unit for administrative and representative purposes. Each union is made up of nine villages, one of which is designated as a ward.

transformative. The sequential type begins with the use of a quantitative or qualitative method that is then followed by the other. For example, a researcher begins with the use of a qualitative method (e.g., focus group discussions) to gather data and then develops their findings by following them up with an enquiry that employs a quantitative method (e.g., a questionnaire survey). The concurrent mixed methods approach applies both methods simultaneously. In a transformative mixed methods approach, the researcher applies a particular theoretical lens to the development a design methodology that contains both qualitative and quantitative data (Creswell & Creswell, 2018). Sporton (1999) contends that it is particularly helpful to combine quantitative and qualitative methods when exploring the process of fertility changes, and this research used sequential exploratory mixed methods: it started with the use of qualitative methods—fieldwork was initiated with key informant interviews and focus group discussions—which were followed by a quantitative household survey. Then, women were invited from the household survey, based on judgment sampling, to participate in further in–depth interviews.

A number of useful examples show how mixed methods approaches have been used in the field of human geography to conduct fertility research. Thomas and Sporton (1997), in their study on population changes and the fertility of women in Kalahari, Botswana, undertook a mixed methods research approach that included questionnaire surveys, in-depth interviews, and ethnographic case studies. In a study on the influence of social determinants on fertility in East and West Germany, Bernardi et al. (2007) applied quantitative and qualitative methods for their data collection and analysis. Buber and Fliegenschnee (2011) studied the fertility intentions of Austrian women and used mixed methods combining in–depth interviews, descriptive statistics, and probit regression. This research, undertaken in the aforementioned villages of Bangladesh, used quantitative (e.g., univariate, bivariate, and inferential statistics) and qualitative (e.g., verbatim quotations) techniques to gather and analyse data. The triangulation of both quantitative and qualitative information was a useful tool to illuminate and validate research findings.

3.4 Data sources: Secondary and primary

This research collected primary qualitative data from focus group discussions, participant observations, key informant interviews, and in-depth interviews, and collected quantitative data through a structured, face-to-face questionnaire survey. Secondary data to support the research included documents, journals, online databases, maps, reports from the local clinic, hospital, government offices, and journals. Essential to this study, climatic variabilities such as temperature and rainfall data were collected from the Bangladesh Meteorological Department (BMD), extreme climate events such as cyclones, floods, droughts, and extreme temperature events data were collected from the Centre for Research on the Epidemiology of Disasters (CRED), data on total fertility rates were collected from the World Bank.

3.5 Target group and sampling formula

The fieldwork was done in three different phases (described in detail in 3.7), each of which required the use of a specific technique (see *Appendices D, E, F, G*) to target unique population groups within the selected villages.

Phase One included key informant interviews with experts and focus group discussions with selected village-dwellers. Four key informant interviews were held in each selected upazila with the Upazila Nirbaahee Officer (UNO), the Upazila Family Planning Officer (UFPO), the Branch Manager of World Vision, and several Family Welfare Assistants (FWA). Focus group discussions were then held with participants from the general village population, including farmers, fishers, business owners, teachers, health professionals, village elders and leaders, and members from the Union Disaster Management Committee. This research conducted five focus group discussions with men in each of the two selected villages; thus, a total of ten focus groups were held. Respecting the gender-sensitive socio-cultural environment in rural Bangladesh, women were not considered at this stage to participate in discussions held in public places. Each focus group discussion was held with between eight and 12 male participants. This means a minimum of 40 and a maximum of 60 participants were involved in each of the two selected study sites. Focus group discussion participants were village residents aged over 18 years.

Phase Two applied a simple random sampling technique to select married women from the village of reproductive aged 18 to 49 years, with at least one or more children and currently living with their husbands, to complete a face-to-face household survey. It is important to note that Bangladesh has a two-children family planning policy. A couple may have two children;

however, families are encouraged to have one. Popular family planning slogans are "either boy or girl, two children are enough", and "not more than two children, one is better." Therefore, married women aged 18 to 49 with at least one child and currently living with their husbands were expected to know whether they wanted to have another child and what determinants or circumstances would allow them to do so. Previous studies in Bangladesh have used the same criteria for including women as respondents (Alam et al., 2018; Biswas et al., 2017; Haq & Ahmed, 2019).

Household surveys were distributed to eligible women in each village, according to the criteria as mentioned above; these women formed the population for the survey. The representative sample size[8] was drawn from the population with a 99 percent confidence level, a standard error of 0.01941 with a relative standard error of 3.88, and a proportion of 0.5 (upper and lower limits are 0.55000 and 0.45000). From the two villages, 544 women met the stated criteria. The overall survey sample included 318 women from Chadnimukha (313 responses, 5 missing) and 231 from Lamagaon, out of populations of 611 and 355, respectively. The married women who participated were choosen randomly (*Appendix H*) through a random number generator software, "Research Randomizer"[9]. The household survey asked for information about all household members, including fertility intentions, birth histories, and child mortality, and targeted the female of the household to provide the most accurate information. However, if any woman could not provide accurate information, or if they preferred another householder to assist in filling out the survey, the most well informed or senior person of the household (husband, father, mother, brother/sister, and in-law family members) were asked to help. The researchers returned to the selected women until a household survey interview was completed. During fieldwork, five women in the Gabura union were absent from the household. No substitution of the selected women was made. Therefore, the response rate was 99 percent.

Phase Three recruited married women from a subset of surveyed households to take part in in-depth face-to-face interviews. These interviews were conducted with a subset of household survey participants who expressed a willingness to participate. The selection of in-depth

[8] This research used the online sample size calculator as provided at the website of Australian Bureau of Statistics. The link is https://www.abs.gov.au/websitedbs/D3310114.nsf/home/Sample+Size+Calculator.

[9] Urbaniak, G. C., and Plous, S. (2019). Research Randomizer (Version 4.0) [Computer software]. Retrieved from http://www.randomizer.org/

interview participants was carried out purposively, using “judgment sampling” (Islam, 2008). As Islam (2008, p. 155) explains, “in judgment sampling, individuals are selected who are considered to be the most representative of the population as a whole. It is a judgment sampling because the choice of the individual units depends entirely on the sampler, who, on his judgment, decides the sample be selected that conforms to some criteria” (p. 155). A previous study exploring the climate change impact of vulnerable coastal populations in Bangladesh also used judgment sampling to select participants for focus group discussions (M. I. Kabir et al., 2016). From the initial analysis of survey data, certain patterns emerged that were investigated further with these in-depth interviews. Some important criteria upon which the researcher used judgement to select women for in-depth interviews were experience and perceived risk of extreme climate events and child mortality, gender preference for future children, unplanned pregnancies, household vulnerability, and access to health facilities. In the end, 48 and 26 women from villages hit by cyclones (Chadnimukha) and floods (Lamagaon), respectively, participated in in-depth interviews, generating a total of 74 in-depth interviews.

3.6 Pre–testing the questionnaire

A pilot study, also referred to as a feasibility study, is a version of the study trialled with a small number of sample participants before the intended study is conducted (Arain et al., 2010). A pilot study also involves executing a pre-test of particular research instruments, including questionnaires and interview schedules (Baker & Risley, 1994). The pre-testing of a questionnaire is considered to be the surest protection against the possibility of errors with the designated questionnaire (Babbie, 2020).

The researcher of the study met Family Welfare Assistants (FWAs) of the selected villages before commencing data collection, to discuss the survey questionnaire and interview schedules for coherence in the local language. The FWAs helped the researcher to employ proper terminology, which aided in the execution of the household survey and in-depth interview by the female research assistants. The initial questionnaire conducted by female research assistants was pre-tested on 20 households in each village. Pilot testing was conducted in both areas so that the questionnaire would be applicable, despite the differences between the two villages. This pilot testing helped develop a standard questionnaire suitable for use in both flood-prone and cyclone-prone areas. The original questionnaire and in-depth interview checklists were translated into Bengali by the researcher.

For this research, the pretesting of the questionnaire was pivotal, for a number of fundamental reasons. First and foremost, the initial survey questionnaire had been developed in English and then translated into Bengali, the national language of Bangladesh. Therefore, it was necessary to ensure that nothing had been lost in translation, that the questionnaire was easily comprehensible to and readable by the research assistants and participants. Pre-testing the questionnaire enabled the researcher to employ words which were used in everyday language by research assistants and participants. It also helped the researcher to identify words used in the local dialects of participants to refer to the climatic hazards, so these could be incorporated in the revised questionnaire. This pre-test assisted in calculating the proximate amount of time it would take to conduct the survey, which assisted with planning, and was a great help in the training of research assistants. Equally important, the pre-test also helped determine the logic and flow of the questions to maintain a story and frame, enabled a crosscheck for repeated and unnecessary questions, and, ultimately, confirmed the cohesion of the questions. The response codes were also reviewed through this process; for example, asking the occupation questions entailed the use of several response codes, and this was made more comprehensible through the pre-test.

3.7 Data collection

As previously mentioned, once the villages had been selected, fieldwork to collect data was conducted in three phases.

3.7.1 Phase one: profiling vulnerabilities to extreme climate events

The first phase of the study aimed to identify areas most vulnerable to extreme flooding and cyclone events and to explore particular areas of vulnerability. The research began with the initial conducting of four key informant interviews (KIIs) in each of the selected upazilas of Shyamnagar and Tahirpur (Table 3.4), for a total of eight KIIs. The KII 1 with each local Upazila Nirbahi Officer (UNO) helped with the selection of the unions and villages most highly vulnerable to floods and cyclones. The aim of this interview was to gain an overview of the selected upazilas, their vulnerability to extreme climate events, and identification of the most highly vulnerable unions and subsequent villages. The KII 2, with an Upazila Family Planning Officer (UFPO), aimed to explore the region's family planning issues. The third KII, with one of the leading NGOs in each village, focused on women's reproductive health and child nutrition. The last KII was with the local family planning worker (FWA) of each village, to discuss their family planning services and their work with local married women.

Table 3.4 Participants of key informant interviews.

KII No.	Name of KII	Targeted expert
KII 1	KII with Upazila Nirbahi Officer (UNO) or Project Implementation Officer (PIO) to gain an overview of the upazila and its vulnerability to extreme climate events and to select highly vulnerable areas for study	Upazila Nirbahi Officer (UNO) or Project Implementation Officer (PIO)
KII 2	KII with Upazila Family Planning Officer (UFPO) to identify the family planning issues of the upazila and study area	Upazila Family Planning Officer (UFPO)
KII 3	KII with World Vision NGO officer to explore local issues associated with women's reproductive health and child nutrition	Branch Manager
KII 4	KII with Family Welfare Assistant (FWA) to discuss family planning services	Family Welfare Assistant (FWA)

This research informed all parties of the research in this initial phase. Doing so with the Family Welfare Assistant (FWA) of the selected villages was particularly relevant, as FWAs visit households once every two months to meet with married women of reproductive ages who are currently living with their husbands. After their KII, the FWA of each village was asked to distribute the *Participant Information Sheet* to inform the participants about the research and invite their voluntary participation in focus group discussions.

For the next step of this phase, this research adopted climate vulnerability and capacity analysis (CVCA) methodology, which is used to analyse vulnerability to climate change and extreme climate events at the community level through a participatory research approach (Dazé et al., 2009). The CVCA activities, undertaken to help the researcher build a profile of each village, were conducted in the form of focus group discussions (Beazley & Ennew, 2006) on the subjects of historic disasters, seasonal and occupation calendars, hazard mapping, perceptions of climate change, and roles played by children and adults during disasters. Each focus group discussion included eight to 12 male respondents from different groups to represent the village society, including the social elite, wealthy groups, knowledgeable persons, members of the

Union Disaster Management Committee, and those in a range of occupations. Females were neither considered nor invited to the focus group activities, as they were undertaken in outdoor or public places in which women were generally excluded because of the gender-sensitive norms and values in rural Bangladesh.

Each topic of the focus group discussions was intended to reveal information that would be key to the next phase of the research. Discussion of past disasters helped the researcher access comprehensive information regarding both extreme climate events that had occurred in the village in the past and what residents expect to face in the future. Talking about the villagers' typical experience of employment through the seasons aided the identification of changes in seasonal activities for households and pinpointed times when men migrate temporarily (seasonally) for a few days or longer in order for the researcher to determine when men are available at home and spend most of their time with their family members. The objective of hazard mapping was to increase the researcher's familiarity with the study areas, the particular areas at risk from cyclones or floods, and the observed changes in such hazards. Two other focus group discussions with the community's male members were held to discern their climate change perceptions and their gender preferences for children in relation to extreme climate events.

A focus group discussion is a semi-structured dialogue in which four to ten people participate and discuss a broad range of issues (Liamputtong, 2019). The discussions generally commence with the moderator(s) asking a broad question before moving to a focal or specific question. Participants are encouraged to share their opinions and thoughts (Krueger, 2014). The interaction between the participants allows respondents to clarify their individual positions and finally come to shared perspectives (Morgan, 1988).

Before the focus group discussions were held for this research, farmers, fishers, business owners, teachers, health providers, local elders, knowledgeable persons, and the chief of each village were invited to participate through the distribution by the family planning worker of a *Participant Information Sheet.* The family planning workers were chosen to make this initial contact because they knew the villagers well and so were able to identify suitable potential participants for the focus groups. Focus groups were held in a central public location in each village. In the first sessions, the focus group participants explored and defined a disaster profile of their village using a range of discussion tools. There were five focus groups on different themes in each village; thus, a total of ten focus group discussions were held (see Table 3.5).

Table 3.5 Details of focus group discussions undertaken in both study areas.

Focus group no.	Themes	Purposes	Number of participants	Age and sex	Occupations
1	Village disasters historical timeline	▪ Provide an overview of past hazards and changes in frequency, intensity, and impacts over time.	12	Male villagers 18 years and over	Farmers, fishers, business owners, teachers, health providers, local elders and other knowledgeable persons, and the chief of the village
2	Seasonal and occupational calendar	▪ To understand typical livelihood and seasonal activities and changes over time.	10		
3	Hazard mapping	▪ To identify areas which are at risk from cyclones or floods.	12		
4	Climate change perceptions of males	▪ To understand the climate change perceptions of males.	12		
5	Roles played by children and adults during a typical extreme climate event	▪ To understand preferences for boy or girl children who can assist families before, during, and after extreme climate events. ▪ To understand the roles played by men and women during extreme climate events.	8		

3.7.2 Phase two: household surveys with ever–married women of reproductive ages

After the focus group discussions were completed, the *second phase*, a household-level survey was conducted face-to-face through a questionnaire, was undertaken. Babbie (2020) defines questionnaire is an important tool which is designed to extract information that will be useful for analysis. Women eligible to participate in the survey had at least one child and were currently living with their husbands. Based on the inclusion criteria, women were selected from the villages using family planning registration records from the local family planning office. Women were selected for surveying (second stage) and for interviews (third stage) because they are the target group of family planning initiatives in Bangladesh. Family welfare assistants working in rural areas visit married women of reproductive age to discuss their reproductive and child health, provide information about family planning issues, and deliver free contraception. Women know their childbearing history better because they have children and are easily accessible in rural areas. Women were asked in the survey to provide demographic and health information about the householders, the households' vulnerability, impacts of and losses from extreme climate events, experiences and perceptions of extreme climate events in general, birth histories of all children, and child mortality. The interviewers—four female research assistants who resided in the selected areas—asked the respondents the questions orally and recorded their responses according to the given response codes. They completed graduation in social sciences from public, private and national universities in Bangladesh, had excellent knowledge of research methods, had experience working with mothers and children in their area for reputed international NGOs, and were highly skilled in conducting surveys and interviews, and were trained in research ethics protocols and data collection methods before conducting surveys and interviews.

3.7.3 Phase three: in–depth interviews with a subset of women from the household surveys

As interviewing is a conversation with a purpose, women for the in-depth interviews that followed the survey questionnaire interviews were selected using judgment sampling. The participants' views, considered valuable and useful (Marshall & Rossman, 2006), were respected by the interviewer. This was a semi-structured interview, with discussion themes that had emerged through the surveys related to the perceptions and experiences of extreme climate events, experiences of birth and mortality of children, and intentions and reasons to have more children. Notably, those who had a higher number of children ever born, had experienced child mortality, had relevant stories regarding the effects of extreme climate events, and intended to have more children were prioritised for consideration for these in-depth interviews.

3.8 Ethical considerations

The Human Research Ethics Committee (HREC) of the University of Adelaide reviewed and approved the research protocol for this study: the ethics clearance number is H-2019-077, and the approval letter from the HREC is attached in the Appendix (*Appendix I*). The nature and purpose of the research were explained, fully and clearly, to all participating respondents through the provision of a *Participant Information Sheet* (*Appendix J*), the written information on which was also directly explained to them orally. After clarifying their understanding of the *Participant Information Sheet*, their written consent to participate in the project was sought and obtained. The consent form (*Appendix K*), which was also explained to participants in detail, outlined privacy and confidentiality issues and addressed the audio recording of the content, for which consent was also requested. Participation in the research was voluntary, and participants were able to withdraw their participation at any stage.

3.9 Data analysis

This research employed a mixed method approach to the analysis of the collected quantitative and qualitative data. Quantitative analysis techniques included descriptive and inferential statistics as well as path analysis. Descriptive statistics were used to present characteristics such as age, income, education, and number of children. Analysis of the data using inferential statistics included application of the Chi-square and ANOVA tests. Cross-tabulations were used to explore the associations of categorical variables, and Chi-square was measured to establish differences. Path analysis was employed to reveal the significant association between variables. Generalised linear regression, binary probit regression, and multinomial logistic regression were used to reveal the selected determinants associated with the fertility of women and their intentions to have another child. The IBM SPSS version 25 for statistical analysis, ArcMap version 10.6.1 for creating maps, MAKESENS program for climate data analysis, and Microsoft Excel 2016 for creating figures were used and accessed through the University of Adelaide. Details of the analysis of the data follow.

Household vulnerability was measured by an established climate vulnerability index (CVI), which was developed by Pandey and Jha (2012) through experiments conducted in rural communities in India. This index considers three dimensions and associated components that determine the vulnerability of the household: exposure, sensitivity, and adaptive capacity. The *exposure* dimension includes two major components—extreme climate events and climate variability; *sensitivity* includes three major components—health, food, and water; *adaptive capacity* includes three major components—socio-demographic profile, livelihood strategies, and social networks.

Meteorological data for the Satkhira and Sylhet districts were analysed using the Mann-Kendall test to detect and forecast trends in rainfall and temperature. The MAKESENS software, designed by the Finnish Meteorological Institute, was used to derive Mann-Kendall test statistics. This test is recognised as a powerful tool for detecting monotonous trends of data that are not normally distributed. In addition, the slope estimator of the non-parametric Sen (Q) was utilised to calculate and identify the degree and direction (positive or negative) of the trend. A 10 percent error margin and a 90 percent confidence level were considered to determine the significance of trends.

Path analysis indicates various causalities in variables which can be represented graphically using arrows and circles. In this study, path analysis was undertaken to predict regression weights. Coefficients derived from the path analysis are generally accepted to serve as standardised regression coefficients that can differentiate one variable from another. Path analysis was performed in SPSS using an additional module called "Analysis of Moment Structures" (AMOS). The path analysis of this study considers the desired fertility of women as an endogenous variable, expecting that it would be possible for them to achieve the desired outcomes before their menopause, and that their perceptions of extreme climate events could affect this. In that case, the construction of the regression model might be biased, as it has been designed to understand women's current fertility only through their perceptions of extreme climate events.

To compare regression models, the Akaike information criterion (AIC) and the Bayesian information criterion (BIC) were employed, because they are widely used in the selection of better models. Models are considered to be better when the AIC and BIC have smaller values. It has been suggested that a difference of more than 10 in the AIC or BIC value in two different models could identify the superior one with a smaller value. Moreover, a moderate degree of superiority of one model over others is suggested if the value difference is between 4 and 10.

A difference of less than 4 indicates that the competing models cannot be distinguished (Pan, 2001).

Qualitative data in the form of field notes and audio recordings were transcribed into protocols and transcripts and encoded via NVivo quality data management software. Interview recordings were transcribed by a professional translator with experience in transcribing social research interviews. Audio recordings were transcribed without any commentary on the participants' behaviour (e.g., anxiety, frustration), but captured all verbal content expected to be relevant to the analysis, including dialect and filler words. The researcher collected the translations and carefully went through them to become familiar with the data (Riessman, 1993), generate code for the relevant information, and extract the relevant statements using NVivo. Protocols and transcripts were coded and one or more distinguished summaries of each transcript were developed to keep the content of a sentence or paragraph consistent. The coding process is considered part of the qualitative analysis (Miles & Huberman, 1994) because it helps organise data into meaningful groups or patterns (Tucket, 2005). Interview quotes were used to develop a new section of findings as needed or as a complementary quantitative data. A list of the participants in the focus group discussions and in-depth interviews whose quotations have been included throughout the study is provided in the Appendix (*Appendix L*).

3.10 Conclusions

This chapter outlined the selection process that identified the two villages in Bangladesh, one with extreme experience of cyclones (Chadnimukha) and the other with extreme experience of floods (Lamagaon), in which fieldwork was conducted in 2019 and 2020. These study villages were systematically selected through a multi-stage process to ensure their representativeness as areas exceptionally vulnerable to extreme cyclones and floods, in order for the research to identify and generalise the distinct ways in which a particular type of climate-related disaster event can influence the processes of fertility.

As it is considered fruitful to incorporate quantitative and qualitative methods in studies of fertility processes, this chapter discusses the relevance of the use of a mixed methods approach to investigate how extreme climate events influence family intentions and decisions about ideal numbers of children. The various methods undertaken in this study for the collection and analysis of both quantitative and qualitative data were described in detail .

It proved quite challenging to conduct field surveys in cyclone and flood risk areas in which even the researchers may have to confront the danger. The weather, climate, and associated risks were thoroughly considered and monitored over the course of the field survey. To reduce the likelihood of being exposed to cyclones or floods during the collection of data, the cyclone-hit village was visited by researchers between July and September (as there had never been a cyclone in the area during this period), and the flood-hit village was visited between November and January (during the dry season in the wetlands).

Chapter 4 The Vulnerability of Study Villages to Extreme Climate Events

4.1 Introduction

This chapter provides a description of the vulnerability of the villages used in this study (Chadnimukha and Lamagaon) to cyclones and floods. This research adopts climate vulnerability and capacity analysis (CVCA) methodology, which is helpful to analyse the vulnerability of communities to climate change and extreme climate events. CVCA is a process of collecting information focused on climate change, hazards, vulnerability, and impacts through a participatory research approach that engages community members and analyses that information in a way that can provide steps to build adaptive capacity and build resilience to climate change and extreme weather events. The CVCA activities used to develop an understanding of the study areas were conducted in focus group discussions with local male participants on topics including hazard mapping and the history of disasters experienced in the area as well as the typical local seasonal and occupational calendar. This chapter commences with an overview of the study areas, which is then followed by a description of the community's vulnerability to extreme climate events. It then discusses the demographic, economic, and social characteristics of the respondents and their households. The determinants related to extreme climate events that can influence the fertility behaviour of women is discussed next. It is also important here to understand the general health of women and family planning access and facilities.

4.2 Local vulnerability to extreme climate events as identified by participants

4.2.1 Hazard mapping for extreme climate events

The *Gabura* union is located beside the mangrove forest *Sundarbans* in the *Shyamnagar* sub–district of the *Satkhira* district. The union is bounded by Sundarbans mangrove forest on two of its sides. Two rivers flow around the study area: the *Kopataska River* flows on the northwest side, and the *Kholpetua River* streams along the southeast side. The villages located near each river are vulnerable due to storm surges that occur when cyclones make landfall.

Figure 4.1 indicates the vulnerability of one of the chosen villages for this study, *Chadnimukha*, to cyclones. It shows that the village has the *Kholpetua River* in the south, the villages of *9 No Sora* in the west, *10 No Sora* in the north, and *Napitkhali* in the east. The south side of the embankment in this village is intensely vulnerable to cyclones, with the cropping area vulnerable to seasonal drought and salinity in soil and water. The villagers use the primary school, which was built to serve multiple purposes, as a cyclone shelter. The villagers do *gher* farming, which involves transforming a paddy field into a shrimp farm by creating elevated embankments across the fields and digging a canal a few feet deep within the enclosure to reserve water in the dry season.

Figure 4.1 Hazard mapping, the cyclone–hit village of Chadnimukha.

Source: Author’s construct using Google Earth.

In contrast, the other village chosen for this study from the union of *Sreepur South*, *Lamagaon*, is a severe flood-prone village as shown in Figure 4.2. The east of the village is *Ramsinghopur*, and the *Monai River* crosses the village in the east–south direction. The northwest side of the village is *Tangoar Haor*. Haor is a bowl or saucer-shaped wetland ecosystem that catches runoff water during the rainy season and becomes a broader area of often turbulent water. During the flooding season, the village turns into an island, with the northeast and northwest side of the village very highly vulnerable to floods and the vegetation areas vulnerable to thunderstorms and hailstorms. The villages *Ramsinghopur* in the east and *Mohjompur* in the south occasionally protect the village from floods.

Figure 4.2 Hazard mapping, the flood–hit village of Lamagaon.

Source: Author's construct using Google Earth.

A male high school teacher aged 40 years during the focus group discussion stated that:

> *When there is a flood, our village's northwest side is significantly affected since the flood water comes from the Tangoar Haor, which is northwest of our village. The areas that were at risk in the past are still at risk now. You may know about the Tangoar Haor, a large bowl of water that remains underwater for several months each year. The current of floodwater makes it seem like an ocean. You will not see the end of the wetland. (Participant 1, FGD, flood–hit village of Lamagaon)*

4.2.2 Extreme climate events in the study villages

In one session of the focus group discussions, participants discussed and created a list of the cyclones/floods they had experienced in Chadnimukha and Lamagaon and ranked these according to their intensities and their overall impacts on the community. Table 4.1 provides details of these results from the focus group discussion held in Chadnimukha. These cyclone records, presented as a timeline between 1988 and 2019 that reports the occurrence of nine devastating cyclones in the last 30 years, provides detailed information regarding the villagers' experience of cyclones and their impacts in the village and informs what villagers may expect to face in the future. Focus group discussion participants also stated that this area is vulnerable to other disastrous events, including tidal waves (which result in soil and groundwater salinity), erosion, and droughts.

Table 4.1 Cyclones in Chadnimukha, 1988–2019.

	Year	Rank	Cyclone name/description	Overall impacts on the community
1	2019 (9 Nov)	5	Bulbul	• Crop damage • Shrimp farming severely affected • Partial damage to houses and properties
2	2019 (4 May)	6	Fani	• Partial damage of a few houses • Some trees collapsed
3	2012 (6 Apr)	7	Convective storms	• Partial damage to a few houses
4	2009 (27–29 May)	1	Aila	• Every household experiences loss • Massive crop loss • Full and partial damage to many houses • 98 percent of kutcha houses were fully damaged • Damage of roads and infrastructure • Loss of livestock • Villagers take shelter on embankments for months • 20 percent of villagers migrate to elsewhere from the village
5	2009 (19–21 Apr)	8	Bijli	• Minimal damage to the village • Shyamnagar and Assasuni Upazilas from Satkhira district are the worst affected by Cyclone Bijli • Significant damage in the area is associated with damage to embankments and displacements of people in Shyamnagar and Assasuni Upazilas
6	2007 (15 Nov)	3	Sidr	• Partial damage to a few kaccha houses • Full damage to a few kutcha latrines • Some trees collapsed
7	1998 (19–22 Nov)	9	Cyclonic storm	• No reported or observed damage
8	1991 (29 Apr)	4	Cyclone Gorky	• Wind damage reported in the southwestern coastal districts of Bangladesh (i.e. Khulna and Satkhira) • Damage to houses • Loss of livestock
9	1988 (24–30 Nov)	2	Severe cyclonic storm with a core of hurricane wind	• Several death • Full damage of crops • Full and partial damage of many houses • Loss of livestock

Source: Focus Group Discussions, 2019–2020.

A fisherman aged 25 years reported that:

> *The region's extreme climate events are storms, floods, riverbank erosion, cyclones, droughts, and salinity in soil and water. The soil's salinity does not allow us to cultivate various crops like other parts of Bangladesh do. (Participant 2, FGD, cyclone-hit village of Chadnimukha)*

A 42-year-old male entrepreneur who operates a small business added:

> *The most dangerous disaster is a cyclone, which happens almost every year. We see a devastating cyclone every three or five years. The other extreme climate events, such as storms, floods, riverbank erosion, salinity, drought, etc., do not affect us significantly as a cyclone can. (Participant 3, FGD, cyclone-hit village of Chadnimukha)*

A fisherman aged 25 years described the devastating impacts of cyclone Aila in 2009.

> *Cyclone Aila is the most destructive one I have ever seen in my life. We can say there was nothing left after the cyclone; we lost whatever we had. Almost every house was either fully or partially damaged. There were many kutcha houses, almost 98 percent of them entirely vanished. There were losses of livestock, trees, and other property. Cyclone Aila damaged local public infrastructure as well. The villagers had to take shelter on our village's embankments—there were no other safe places left to take shelter. Moreover, after this devastating Cyclone Aila, 20 percent of our villagers left the village to look for a better life. No one in our village had imagined such destruction would come to ruin our life and everything. (Participant 2, FGD, cyclone-hit village of Chadnimukha)*

Roy et al. (2009) identified the twelve worst affected districts by Cyclone Aila as Satkhira (which contains Chadnimukha village), Khulna, Bagerhat, Pirojpur, Barisal, Patuakhali, Bhola, Laksmipur, Noakhali, Feni, Chattogram and Cox's Bazar (Roy et al., 2009). Focus group participants ranked the unnamed 1988 cyclone as the second most devastating cyclone, followed by Cyclone Sidr in 2007. They agreed that they have experienced an increase in the occurrence of cyclones in recent decades, and all anticipated that they would experience more in the future.

Exemplifying this expectation, a male farmer aged 45 years said:

> *We think the numbers will increase. Though we are not scientists, we are predicting this based on our experience and the trends of past cyclones and the dramatic changes of climate variability. The frequency and severity of cyclones are increasing, and make our lives and livelihoods uncertain now and in the future. (Participant 4, FGD, cyclone-hit village of Chadnimukha)*

Table 4.2 presents a summary of the historical timeline of floods in Lamagaon, as described by focus group participants from this village. Six devastating floods impacted this village in the last 30 years, with the top-ranked flood occurring in 2004. This village is also vulnerable to other hazards such as storms, hailstorms, and seasonal drought. The focus group participants described in detail the adverse impacts the floods have had on their livelihoods.

Table 4.2 Floods in Lamagaon, 1988–2019.

	Year	Rank	Overall impacts on the community
1	2019	5	• Deaths of a few people • No loss of growing crops • Little loss of stored crops • Damage to houses and property
2	2017	2	• Deaths of a few people (“4 or 5”) • Massive crop losses • Loss of livestock • Damage to houses and property
3	2010	6	• Massive loss of crops • Damage to houses • Damage to roads
4	2004	1	• Several deaths • Loss of crops • High water levels throughout the village • Damage to houses and loss of property
5	1994	4	• Loss of livestock • Damage to houses
6	1988	3	• Several deaths • Full crop damage • Loss of livestock • Damage to houses

Source: Focus Group Discussions, 2019–2020.

A Lamagaon fisherman aged 25 said:

> *The most frequent extreme climate event in our village is the flash flood* [Agam Bonna]. *This happens before the regular flood times* [in May], *mainly early in April. In April, we, especially farmers, are busy with harvesting and processing rice from the land that starts getting inundated in May. (Participant 5, FGD, flood-hit village of Lamagaon)*

A 34-year-old male primary school teacher added:

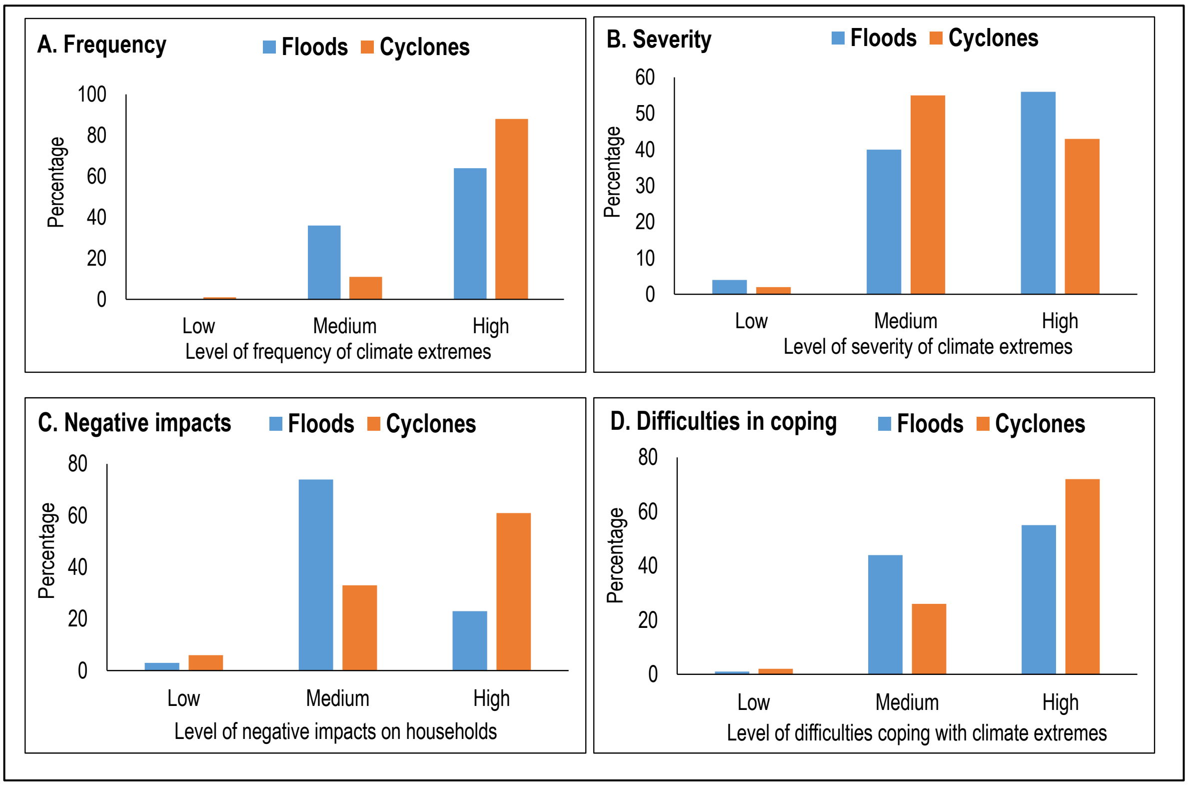
> *We can say that floods, storms, and droughts are notable extreme climate events in our village. We do not experience other extreme climate events such as earthquakes, river erosion, landslides, salinity, or sea-level rise. Of the extreme climate events, the flood is the extreme and regular one that severely impacts our lives and livelihoods. The other events, storms and droughts, are not severe or do not impact our community. (Participant 6, FGD, flood-hit village of Lamagaon)*

A male farmer aged 37 described the effects of flooding events:

> *Flash flood damages our Boro rice production. The paddy planting of Boro begins from October to November, and the rice is harvested from April to June. However, we prefer the fastest growing type of rice seed suitable for our weather and flood conditions. There is nothing to solve the problems of rice production loss and damage due to flash floods, despite the innovative advances in rice cultivation technology in Bangladesh. (Participant 7, FGD, flood-hit village of Lamagaon)*

As described in Chapter 3, focus group discussions were followed by household surveys intended to build upon and deepen knowledge of the impacts of the cyclones and floods on the local people, and, specifically, on their fertility decisions and intentions. The results of the household surveys conducted in both villages that are relevant to the experience of cyclones and floods are presented in Figure 4.3. The findings shown across four graphs confirm the perceptions and experiences that were shared in the focus group discussions regarding the frequency, severity, negative impacts, and difficulty villagers had coping with cyclones and floods. While the experiences of floods and cyclones differed, overall, these extreme climate events were clearly severe, had significant adverse effects on households, and were difficult to highly difficult to cope with.

Figure 4.3 Frequency, severity, negative impacts, and difficulty in coping with extreme climate events in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).



Source: Household Survey, 2019–2020.

4.2.3 Seasonality of extreme climate events

In a separate focus group discussion, participants discussed the seasonality of hazards in the cyclone-hit village (Chadnimukha) and the flood-hit village (Lamagaon), and developed seasonality calendars for their areas (Tables 4.3 and 4.4). Although Bangladesh has been known as a country that had six seasons in the past—winter, spring, summer, rainy season, autumn, and late autumn—focus group participants agreed that, now, there are three main noticeable seasons in Bangladesh: winter, the rainy season, and summer.

As shown in Table 4.3, according to the focus group participants from Chadnimukha, January and February are the winter months, and mid-March to mid-November are perceived to be summer, which includes the rainy season from mid-May to mid-August. The focus group participants noted that the temperature remains extremely high from mid-April to mid-August, and that the rainfall is severe from mid-June to mid-September. This village sometimes experiences fog in winter and drought and hailstorms in summer. The participants also reported the seasonal salinity in soil and groundwater experienced in the dry seasons between October and March. April to May and October to November are the cyclone seasons.

A 30-year-old male participant from Chadnimukha, who works as an NGO worker, said that:

> *There were six seasons in the past, and Bangladesh was well known for its different seasons. However, Bangladesh is no more a country of six seasons. Now it is a country of only three seasons: the rainy season, summer, and winter. Of the three seasons, the summer is the prolonged season—it lasts for several months more than it did in the past. At present, eight months of a year can be regarded as summer. The remaining four months of a year can be regarded as the rainy season and winter, two months for each. (Participant 8, FGD, cyclone-hit village of Chadnimukha)*

In the flood-affected village of Lamagaon, as shown in Table 4.4, the participants reported a prolonged summer that includes the rainy season (mid-June to mid-September). The temperature of the surrounding area remains extremely high between mid-April and mid-August. The villagers experience fog at the end of winter and hailstorms at the beginning of summer. This part of Bangladesh is vulnerable to severe thunderstorms from mid-March to

Table 4.3 Seasonality calendar of the cyclone–hit village of Chadnimukha.

Hazards	**English month**	**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
	Bengali month		**Mag**		**Fal**		**Cha**		**Bai**		**Jai**		**Ash**		**Sra**		**Bha**		**Ash**		**Kar**		**Agr**		**Pou**
	Past season	**Winter**			**Spring**				**Summer**				**Rainy season**				**Autumn**				**Late Autumn**				
	Current season	**Winter**					**Summer**				**Rainy season**[1]						**Summer**								
Extreme temperature (high)																									
Rainstorm																									
Fog																									
Hailstorm																									
Cyclone																									
Tide																									
Soil salinity																									
Groundwater salinity																									
Surface water salinity																									
Drought																									
Arsenic in drinking water		Arsenic may be found any time of the year; the villagers mainly rely on rainwater harvesting and freshwater ponds for drinking water.																							

Note: [1] this rainy season includes the summer months as well. *Source:* Focus Group Discussions, 2019–2020.

Table 4.4 Seasonality calendar of the flood–hit village of Lamagaon.

Hazards	**English month**	**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
	Bengali month		**Mag**		**Fal**		**Cha**		**Bai**		**Jai**		**Ash**		**Sra**		**Bha**		**Ash**		**Kar**		**Agr**		**Pou**
	Past season	**Winter**			**Spring**				**Summer**				**Rainy season**				**Autumn**				**Late Autumn**				
	Current season	**Winter**			**Summer**								**Rainy season**[1]						**Summer**						
Extreme temperature (high)																									
Rainstorm																									
Fog																									
Hailstorm																									
Flash flood																									
Monsoon flood	*Borsha*																								
	Bonna																								
Thunderstorm																									
Drought																									
Sedimentation		A local extreme event, but the study village does not experience the sedimentation and its impacts.																							
Arsenic in drinking water																									

Note: [1] this rainy season includes the summer months as well. *Source:* Focus Group Discussions, 2019–2020.

mid-July. Although not mentioned in the focus discussion group, lightning hazards have been of particular concern in the country in recent years (Dewan et al., 2017; Farukh et al., 2018). The Ministry of Disaster Management and Relief of Bangladesh declared a lightning storm as a natural disaster on 17 May 2016, following loss of life caused by this hazard. It has been found that about 62 percent of lightning strikes occur during the pre-monsoon season (from March to May) (Dewan et al., 2018). Focus group participants described their village as highly vulnerable to flash flooding. The participants of the focus group discussion differentiated monsoon flooding into two types: *borhsa* and *bonna*.

A 40-year-old male high school teacher years clarified the difference between the two types:

> *Flooding is locally referred to as bonna or borsha, depending on the magnitude, intensity of monsoon rain, and time of occurrence, which all vary across regions. Borhsa refers to regular annual flooding, which benefits the paddy rice and other major crops in Bangladesh. This borsha has a limited impact on the local conditions of village dwellers. This borsha turns into bonna when the floods deviate from the characteristics of borhsa regarding timing, duration, and magnitude and induce loss and damage. Thus, local people call unusual floods bonna. (Participant 1, FGD, flood-hit village of Lamagaon)*

A male farmer aged 42 years described typical flood timing and conditions:

> *The flood remains very high for three months each year, between mid-June and mid-September. We cannot go outside the home during these three months. The borsha [regular annual flood] lasts for around six months, from mid-May to mid-November. Sometimes, the agam bonna [flash flood]comes in early April. There is no flood water between December and March, when we plant and harvest rice. (Participant 9, FGD, flood-hit village of Lamagaon)*

4.2.4 Occupational calendar

As part of the above-described focus discussion, participants from the two villages each developed occupational calendars that outline what type of work is generally done at what time(s) of the year. As shown in Table 4.5, the dwellers of cyclone-prone Chadnimukha can only engage in farming for two months (July and August) of the year; they can fish throughout the year. Villagers also work as agricultural and non-agricultural wage labourers during the dry season between October and March. The male members of households typically migrate temporarily within the district in July and August and outside the district from October to March. Other livelihood options reported by focus group participants are pursued throughout the year.

A male fisher from Chadnimukha aged 36 years said:

> *One of our primary livelihood options is fishing. We fish 12 months of the year. We catch crabs and shrimps, which are common in our area. Most of the villagers stay in the village during the rainy season in June, July, August, and September. At this time, some people migrate to other districts for rice harvesting, but the rest of the villagers stay in the village. (Participant 10, FGD, cyclone-hit village of Chadnimukha)*

A 43-year-old male participant working as a day labourer described other jobs the local villagers do:

> *Apart from fishing, a good proportion of dwellers work in the nearby brickfields. They migrate for the brickfield work from October to March in a year when there is no rain. In the meantime, some people go for non-agricultural activities such as earthworks, construction work, transport work, and rickshaw pulling. (Participant 11, FGD, cyclone-hit village of Chadnimukha)*

A male farmer aged 38 years explained the main driver of migration:

> *We do agricultural activities in July and August; we produce Aman rice this time. Some people also do agricultural wage labour this time. In our village, when we cannot do the rice production due to the saline water, people migrate to nearby areas for livelihood. (Participant 12, FGD, cyclone-hit village of Chadnimukha)*

Table 4.5 Occupational calendar, the cyclone–hit village of Chadnimukha.

Occupation	Months											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Farmer												
Fisher												
Agricultural wage labourer												
Non-agricultural wage labourer (earthworks, construction, transport, rickshaw operation)												
Self-employed (as a carpenter or driver of a taxi, pedal-powered rickshaw, van, boat, and/or compressed natural gas-powered auto-rickshaw, known as "CNG")												
Industrial worker (garments and factories)												
Petty small scale trader (bamboo working, handloom weaving, and metalworking)												
Medium to large scale businessperson (jute and textile mills)	N/A											
Seasonal labour migration (within the district)												
Seasonal labour migration (outside the district)												
Overseas migration for employment	N/A											

Source: Focus Group Discussions, 2019–2020.

Table 4.6 Occupational calendar, the flood–hit village of Lamagaon.

Occupation	Months											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Farmer												
Fisher												
Agricultural wage labourer												
Non-agricultural wage labourer (earthworks, construction, transport, rickshaw operation)												
Self-employed (as a carpenter or driver of a taxi, pedal-powered rickshaw, van, boat, and/or compressed natural gas-powered auto-rickshaw, known as "CNG")	N/A											
Industrial worker (garments and factories)	N/A											
Petty small scale trader (bamboo working, handloom weaving, and metalworking)	N/A											
Medium to large scale businessperson (jute and textile mills)	N/A											
Seasonal labour migration (within the district)												
Seasonal labour migration (outside the district)												
Overseas migration for employment	N/A											

Source: Focus Group Discussions, 2019–2020.

Table 4.6 presents the occupational calendar developed by the focus group discussion participants from the flood-prone village of Lamagaon. As depicted, the villagers rely primarily on farming in the dry season and on fishing during the flooding season. They also do agricultural and non-agricultural wage labour in the dry season. They migrate within and outside the district during April and May to harvest rice. The agricultural setting of the village is such that the villagers can harvest rice once a year: the farmers sow the rice seeds between mid-November and mid-December; they till the shoots between mid-December and mid-January; the paddy ripens and the rice is ready for harvesting in April. In 2017, there was a flash flood that submerged the rice under the water; few farmers were able dive down to cut even a few bunches from the underwater paddy. Given the vulnerability and short season of the rice crops, the majority of the villagers rely on fishing to survive. The younger children of households also go fishing and help in the rice paddies with the adult male members. The majority of the villagers stay in the village and do fishing for six months of flooding season. This indicates that the male members of the flood-prone village have a greater likelihood of spending more time with their family members.

A male farmer aged 32 years explained:

> *Agriculture is our main livelihood option. We do farming from November to January and in April and May. November to January is the season of paddy planting, and April to May is the season of rice harvesting. We produce only a crop in a year. We work and are busy for only these four months, and we do not have any work except fishing for the rest of the year. (Participant 13, FGD, flood-hit village of Lamagaon)*

A 46-year-old fisherman said:

> *We do the fishing for the rest of the months when we are not farming. Moreover, fishing is the only source of our livelihood for the flooding season. We fish since we do not have other options. We may not have rice in our house, but there will be fish in the water. (Participant 14, FGD, flood-hit village of Lamagaon)*

Another male participant who typically worked as a day labourer (aged 43) noted:

> *People without any agricultural land work as agricultural wage labourers. In return for their labour, they may receive rice or money, depending on what they need. Most people in our village do not have land. Some of them do sharecropping. Moreover, few people work as non-agricultural wage labourers during the time when others are engaged in rice harvesting. We do not have adequate non-agricultural working opportunities in our village. Both agricultural and non-agricultural wage labourers work during the time when farmers are doing the farming. (Participant 15, FGD, flood-hit village of Lamagaon)*

4.3 Demographic, economic and social differences in the study villages

Because the focus of this research is on the fertility decisions and intentions of women in two villages of Bangladesh, it is necessary to consider and compare key demographic, economic, and social characteristics of these women. Table 4.7 presents the socio-demographic characteristics of the women of cyclone-prone Chadnimukha and flood-prone Lamagaon, as reported in the household survey questionnaires undertaken in both villages with married women who had at least one child and were living with their husbands.

Comparing age statistics at the time of reporting, while the cyclone-affected village had more younger female respondents in the 18 to 24 age category, in both villages, a majority of the respondents were aged between 25 and 34, and just under one-third of them were aged between 35 and 49. Around one in four respondents in both study areas had not received formal schooling; notably, slightly more respondents in the cyclone-hit village had been through secondary and higher secondary schooling than those in the flood-hit village. It was also found that respondents in the flood-hit village were significantly more likely to be married before the legal age at marriage (18 years for girls), at 82.7 percent, compared to their counterparts in the cyclone-hit village, at 59.1 percent. This finding is consistent with a previous study in Bangladesh (Ahmed et al., 2019) that showed that early marriage of girls was higher in a flood-hit area (86%) than in a cyclone-hit area (62%). Increased early marriage is a key determinant that is typically associated with higher levels of fertility.

Table 4.7 Demographic, economic and social characteristics of women in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Characteristics	*Cyclones*	*Floods*
Demographic		
Age (**Mean/Std. Dev**)	**30.35 (6.80)**	**30.66 (7.08)**
18–24	23.4	18.2
25–34	45.0	49.8
35–49	31.6	32.0
Education (%)		
No years of schooling	26.8	23.4
Primary school [levels 1-5]	26.2	34.6
Secondary school [levels 6-10]	33.5	31.2
Higher secondary school [levels 11-12]	13.5	10.8
Age at marriage (**Mean/Std. Dev**)	**17.37 (1.33)**	**16.26 (1.39)**
Less than 18 years	59.1	82.7
18 years or over	40.9	17.3
Frequency of husband's migration (**Mean/Std. Dev**)	1.64 (2.02)	1.19 (1.76)
Duration of husband's migration (months in a year) (**Mean/Std. Dev**)	2.01 (2.41)	1.48 (2.28)
Economic		
Income sources (%)		
Farming	16.9	35.5
Fishing	16.0	42.4
Agricultural wage labour	40.6	13.9
Non–agricultural wage labour	26.5	8.2
Land area per capita (ha) (**Mean/Std. Dev**)	.048 (.047)	.052 (.055)
Social		
Times to closest hospital (minutes)	53.16 (30.62)	16.68 (3.25)
Contraceptive use (%)		
No	22.4	31.2
Yes	77.6	68.8

Note: 1 USD = 86 BDT, as date of 10/4/2022.
Source: Household Survey, 2019–2020.

The frequency and duration of male migration can have a measurable effect on fertility rates, as wives are left behind, alone. According to data from the household surveys, the husbands of the respondents in the cyclone-hit area of Chadnimukha were more likely to migrate and to do so for a couple of months every year, depending on their primary source of income. For example, most of the husbands identified had migrated approximately 1.6 times in the last 5 years, with an average duration of each separation being 2 months. The husbands of the respondents of Lamagaon migrated slightly less frequently, for slightly shorter periods.

Other determinants of fertility rates include access to health care and contraceptives. It is notable that it took more time (an average 53 minutes using the most common mode of transportation) for the cyclone-affected dwellers to reach their closest hospital than it did for those from the flood-hit village (17 minutes). This study found that about 10 percent more respondents in the cyclone-hit area were using contraceptives during the point of survey in 2019 and 2020, which could be due to the interventions of non-government organisations (for example, World Vision) working in the study sites in collaboration with the existing government-facilitated family planning programs. This is described in further detail in sections 4.4 and 4.5.

4.4 Determinants of fertility associated with extreme climate events

The survey questionnaire asked women from both villages a number of questions to identify the impact of extreme climate events on determinants of fertility (Table 4.8). For example, to gauge their expectations of future extreme climate events in their area, the participating women were asked: "Do you perceive there will be another [extreme climate event] in the next five years (2020–2024) that could be as destructive as one of the past?" (Women living in each village were asked about the specific events they typically experience: cyclones or floods). It is interesting to note the consistency with which respondents from Chadnimukha referred to Cyclone Aila in 2009 and respondents from Lamagaon referred to the flood in 2004 to indicate the possible severity of future cyclones or floods. It was found that, while most respondents from both villages expected that another extreme climate event would occur in the next five years, more women in the flood-hit village (82.7%) than those in the cyclone-hit village (75.1%) affirmed this probability.

The frequency with which a household experiences extreme climate events can change their socio-economic conditions, which can in turn affect their planning to have more or less children, as they consider the benefits and drawbacks of having children, given the threat of such extreme events. The questionnaire therefore asked: "How many cyclones or floods have you experienced in the village since you have lived here?" The frequencies of extreme climate events were grouped into three categories: "one", "two", and "three or more". Most respondents in both study areas had experienced three or more cyclones or floods during the time they had lived there. Notably, more respondents in the flood-hit village (84.8%) had witnessed more than two floods than their counterparts in the cyclone-hit village (72.3%) who had witnessed more than two cyclones. In contrast, more respondents in the cyclone-hit village, perhaps the younger participants in the survey, had witnessed only one cyclone.

Table 4.8 Women respondents' experiences of extreme climate events associated with determinants of fertility in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Determinants of fertility associated with extreme climate events	***Cyclones*** **%**	***Floods*** **%**
Perceptions of future occurrence of extreme climate events		
No	24.9	17.3
Yes	75.1	82.7
Frequency of extreme climate events		
One	27.8	15.2
Two	17.3	26.8
Three and more	55.0	58.0
Household's vulnerability to *past* extreme climate events		
Low	26.5	37.7
Moderate	16.0	49.4
High	57.5	13.0
Household's vulnerability to *future* extreme climate events		
Low	11.5	26.0
Moderate	30.4	31.2
High	58.1	42.9
Migration of husbands after an extreme climate events		
No	69.0	86.1
Yes	31.0	13.9
Perceived risk of child death with extreme climate events		
No	23.6	29.4
Yes	76.4	70.6
Failure to access contraceptives with extreme climate events		
No	75.4	74.5
Yes	24.6	25.5
Gender preference associated with extreme climate events		
No	35.1	22.1
Yes	64.9	77.9
Timing of first child with extreme climate events		
There was no extreme climate event	57.5	39.8
Before an extreme climate event	26.8	29.9
During or after an extreme climate event	15.7	30.3

Source: Household Survey, 2019–2020.

The loss and damage associated with past extreme climate events (which have a significant impact on socio-economic status) as well as the perceived vulnerability to such extreme events in the future are likely to influence the adaptive behaviours and planning of members of the household, including women's fertility behaviour and planning for a child. Women were asked to indicate their households' vulnerability to extreme climate events in the past ten years (2009–2018), as these events affected sectors such as agriculture, livelihood, housing, food security, and health. Household vulnerability was classified as "low" if any of these sectors were affected and needed *minor repairs* or a few days to recover. If any two sectors were affected or damaged and needed *some repairs* or a few weeks to recover, household vulnerability was classified as "moderate". If three or more sectors were affected and needed *significant repairs* or a couple of months to recover, household vulnerability was classified as "high". It was found that households in the flood-prone village were less likely to be categorised as vulnerable (37.7% *low* and 49.4% *moderate*) over the past 10 years, with only 13 percent of households in this area considered highly vulnerable to past events. In contrast, 57.5 percent of households in the cyclone-prone village were categorised as highly vulnerable to past events.

To determine the true extent of household vulnerability, which goes beyond the scope of this study, would require the economic assessment of the loss and damage incurred, the assessment and mapping of the affected areas, and calculation of the frequency and intensity of cyclones or floods experienced. This is a worthwhile subject for further study in the future.

Within the scope of this study, because vulnerability to extreme climate events is determined by the exposure, sensitivity, and adaptive capacity of households to such events, the questionnaire asked a direct question to indicate women's perceptions of the vulnerability of their households to future extreme climate events: "Considering your households' socio-demographic and economic characteristics and vulnerability to past extreme climate events, to what extent would you think your household is most likely to be vulnerable to future extreme climate events compared with other households in the village?" Responses to the question were coded as "low", "moderate", and "high". In classifying the anticipated loss and damage from the future extreme climate events, respondents considered the level of their households' vulnerability to past extreme events, the loss and damage that had occurred on previous occasions, the existing systems that enabled their resilience, and their preparedness to tackle the future climatic events. Households in the cyclone-hit area saw themselves as equally or slightly more vulnerable to future events as they were in the past, a percentage choosing "low" was halved, and slightly increased in those choosing "moderate" and "high". In contrast, households in the flood-hit area saw themselves as considerably more vulnerable to future events, with 42.9 percent choosing to describe their households as having a "high" level of vulnerability to future events, in comparison to 13 percent who did so in reference to the past vulnerability, and this is perhaps driven by the expectation of likelihood of a future event.

Because household vulnerability to extreme climate events is considered in this research as a key determinant of fertility, this issue was explored further during the in-depth interview sessions, in which women explained how and to what extent their households had been vulnerable to past cyclones or floods. The interviewees of Chadnimukha explained that, after a cyclone, tidal water typically enters their village unhindered, through an embankment that has collapsed during the storm. When this happens, it does more than just do further damage to the destroyed houses, roads, ponds, crop fields, and home gardens. These tidal water and cyclonic storm surges leave people helpless, with their lives, livelihood sources, shelter, and access to food all threatened. Most interviewees in the cyclone-hit village had witnessed two severe cyclones in 2019: the category 4 Cyclone Fani on 4 May and the category 2 Cyclone Bulbul on 9 November.

The women of Lamagaon explained in their in-depth interviews that households in the flood-hit village are still vulnerable to floods, despite the fact that, every year at the end of April, they typically build and repair temporary protective walls with earthen sacks and bamboo poles around the settlement to protect their houses from the waves of the *haor*. Examples of these protective walls are shown in Plate 4.1.

Plate 4.1 Temporary protective walls around the settlement in flood–affected village of Lamagaon.

Notes: Rectangular shape indicates the area protected with temporary walls. Photos were taken by the researcher [Khandaker Jafor Ahmed] during his fieldwork in the flood-hit village of Lamagaon.
Source: Fieldwork, 2019–2020.

One 28-year-old woman from the flood-hit village who, during the household survey, had classified her household as *highly* vulnerable to the floods in 2017 and 2019 was invited to participate in an in-depth interview. She explained the details of the loss and damage incurred by the floods during the interview session:

> *Our house is right on the bank of Tanguar Haor; the water waves of this haor always hit our house first. During the floods, the water level in the haor increased, and there were strong currents in the water. The destructive waves shattered the protective walls of my settlement. During the floods of 2017 and 2019, about three feet of the protective wall on the northwest side of my settlement collapsed, which will cost around BDT 30,000 (US$ 348, as date of 29 March 2022) to repair. (Participant 5, IDI, flood-hit village of Lamagaon)*

It was found that floods were associated with loss and damage to houses and could influence household decisions, including but not limited to the decision of migration to work and having children.

Given that migration of a family member is considered a determinant of fertility, the household survey questionnaire asked women of both villages this question about the climate-induced migration of their husbands: "Has your husband migrated away from your household for any period lasting at least 3 months, due to any extreme climate event or due to the adverse impacts of an extreme event on your livelihood and/or income?" It was assumed that males were likely to migrate more frequently if the decision to migrate was induced by extreme climate events. It was found that, while the majority of the husbands of respondents in both villages had not been driven to migrate by an extreme event, they were more likely to migrate following or because of a cyclone (31%) than a flood (13.9%). Increasing migration frequencies in the cyclone-hit village would lead to increased incidences of spousal separation, contributing to lower marital fertility.

Cyclones or floods could also influence the risk of child mortality and shift gender preferences, other determinants that affect the fertility intentions of women. The household survey questionnaire asked women about the risk of child death: "Did you perceive there would be a risk of child death associated with the occurrence of climate-related extreme events (e.g., by injury, drowning, or waterborne disease) in the village?" It was found that while the majority of respondents in both villages related extreme events to the prospect of the death of a child, more respondents in the cyclone-hit village (76.4%) perceived this risk to be associated with cyclones than their counterparts living in the flood-hit village associated the risk with flood events (70.6%).

Access to contraceptives is another key determinant of fertility. Failure to access contraceptives during cyclones or floods can lead to unplanned pregnancies and, in turn, have a significant impact on birth rates. To understand the effect extreme climate events had on access to contraceptives, the household survey questionnaire asked women: “Has failure to access contraceptives due to climate-related extreme events resulted in mistimed, unplanned, or unwanted pregnancies and/or live births? Possible impacts of an extreme event include: decreased availability of local health care facilities, medical relief, and aid; damage and disruption of available health care facilities, damage of medicines and contraceptives stored in family planning facilities; and reduced accessibility of transport systems.” A pregnancy is considered *unplanned* or *unwanted* when the parents want no children or no more children, and the pregnancy is *mistimed* if it occurs earlier than desired. Gynaecological problems and pregnancy can induce suffering for women during cyclones or floods. The prospect of suffering or having a bad experience during an extreme climate event is likely to influence the fertility intentions of women who perceive that such events are likely to happen in the future. Importantly, this study found that the failure of one in four respondents in both areas to access contraceptives due to extreme events had resulted in mistimed, unplanned, or unwanted pregnancies and/or live births.

Gender preference and timing of the arrival of the first child are the final determinants of fertility considered in this part of the study. About gender preference, the household survey questionnaire asked: “Which gender of child do you think can help your household during a disaster (e.g., assist in moving to safer places) and help cope with and recover from the disaster?” It was found that respondents in both areas perceive that sons were more helpful than daughters to cope with environmental stress, with more respondents in the flood-hit village (77.9%) indicating this preference for sons than their counterparts in the cyclone-hit village (64.9%).

Women were finally asked to indicate the timing of their first birth with respect to their experience of extreme climate events: (1) there was *no extreme climate event* six months before or after the birth, (2) the birth occurred six months or more *before* an extreme climate event, and (3) the birth occurred *during or* six months *after* an extreme climate event. It was found that more respondents in the cyclone-hit village (57.5%) reported that no cyclones had occurred before, during, or after their first birth. This is likely because catastrophic cyclones typically occur every three years, and a cyclone event is naturally sudden and short-lived. In contrast, more respondents in the flood-hit village (30.3%) reported that their first birth had happened during or after a flood. The duration of a flood can be longer and flash floods can be frequent during flood seasons.

4.5 Health of women, healthcare access and family planning facilities

4.5.1 Health of women

Because general health is another determinant of fertility, the research team sought to assess the health of women participating in the household survey questionnaire by asking questions about their general health. These questions incorporated items from Short Form (SF) 36, a complete series of general, consistent, and easily managed indicators of quality of life developed to provide a concise but comprehensive indicator of general health conditions (Heyde, 2007). Findings reported in Table 4.9 reveal that 14.4 percent of respondents living in the cyclone-hit village of Chadnimukha and 26 percent of those living in the flood-hit village of Lamagaon self-reported their health as “poor”, which stands in particular contrast to the percentages of women declaring their health to be “excellent”: 1.6 percent and 2.2 percent, respectively. Respondents of both areas recorded similar percentages for “fair” and “good” descriptions of their health, however, more respondents from the cyclone-hit village than from the flood-hit village perceived their health as “very good”.

The participating women were asked to respond to a few more statements about their health, along a true-false cline. To the first statement, around a quarter of respondents in the cyclone-hit village and more than a third in the flood-hit village mostly agreed that they get sick more easily than other women. Around half of the respondents in both areas mostly agreed that they are healthy as anybody they know. For the third statement, less than one-fifth of the respondents (18.8%) in the cyclone-hit village and around two-fifths of the women (38.1%) in the flood-hit village mostly agreed that they expect their health to get worse. Interestingly, given their responses to the first question about their general health, a significant percentage of respondents responded "mostly true" to the last of these statements of the survey, "my health is excellent": 45.4 percent and 49.8 percent of respondents in the cyclone-hit village and the flood-hit village, respectively.

Table 4.9 General health of women in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Items	Responses				
1. In general, would you say your health is? **(%)**					
	Poor (5)	**Fair (4)**	**Good (3)**	**Very good (2)**	**Excellent (1)**
Cyclones	14.4	27.5	41.9	14.7	1.6
Floods	26.0	26.0	39.0	6.9	2.2
How true or false is each of the following statements for you? **(%)**					
	Definitely false (5)	**Mostly false (4)**	**Do not know (3)**	**Mostly true (2)**	**Definitely true (1)**
2. I seem to get sick a little more easily than other women.					
Cyclones	14.4	44.1	4.2	24.9	12.5
Floods	13.0	42.9	3.9	35.9	4.3
3. I am as healthy as anybody I know.					
Cyclones	6.4	21.4	3.8	52.4	16.0
Floods	3.9	35.5	3.5	47.2	10.0
4. I expect my health to get worse.					
Cyclones	9.9	34.2	27.8	18.8	9.3
Floods	9.1	43.7	5.2	38.1	3.9
5. My health is excellent.					
Cyclones	13.4	21.1	1.6	45.4	18.5
Floods	24.2	18.6	0.4	49.8	6.9
"General Health" ranking **(%)**					
	Poor	**Fair**	**Good**		
Cyclones	29.1	25.9	45.0		
Floods	41.1	13.9	45.0		

Source: Household Survey, 2019–2020.

Two steps were followed to calculate the scale score of "general health" shown in Table 4.9. First, pre-coded numeric values for each item were re-coded per the direction of items. Items 1, 3, and 5 indicate a woman's positive attitude toward health and items 2 and 4 indicate a negative attitude. Items indicating positive health were re-coded as 100, 75, 50, 25, and 0 for pre-coded numeric values such as 1, 2, 3, 4, and 5, respectively. In contrast, the negative health items were re-coded as 0, 25, 50, 75, and 100 for those pre-coded numeric values. All items were scored in such a way that a high score represented a more satisfactory health condition. Additionally, each item was scored between 0 and 100, so the minimum and maximum probable scores were 0 and 100. In the following step, the scores obtained from the scale items were aggregated to occasion a scale score. To understand the general health of the women surveyed, the scale score was grouped into three: “poor” health for a score of *0 to 33*, “fair” health for a score between *34 and 67*, and “good” health for a score ranging between *68 and 100*. Results indicate that the general health of respondents in the cyclone-hit village of Chadnimukha (70.9% “fair” to “good”) is better than that of respondents from the flood-hit village of Lamagaon (58.9% “fair” to “good”).

4.5.2 Health facilities in the study areas

Access to health facilities is a determinant of fertility that can clearly be affected by extreme climate events. Table 4.10 shows the five nearest health facilities visited by women in the study villages, listed from closest to farthest away. Before comparing access, it is useful to highlight the services and purposes of the health facilities available to both villages. A community clinic is the nearest-available health facility. Community clinics actively provide free contraceptives and other incentives to help women of reproductive ages plan their pregnancies. The Family Welfare Assistants (FWAs) who operate from the community clinics visit the households to maintain family planning registration records. After a few weeks of marriage, FWAs usually reach out to newly married women to discuss family planning issues and provide contraceptives and other services. The FWAs also discuss the mother’s health and the antenatal care that the community clinic provides. In addition, the FWAs provide free contraceptives to women who want to stop bearing children.

The Health Inspector (HI) and FWA usually reside in the village and typically live adjacent to the community clinic. Local pharmacies and doctors, if available in a village, can offer prescription and over-the-counter medication and general health advice and assistance. Of the other health services listed in Table 4.10 of greatest interest is the Union Health and Family Welfare Centre (UHFWC) which are in proximity to rural populations and provides essential services such as family planning, menstrual regulation, vaccinations, and in general, reproductive, and maternal health services.

Table 4.10 Nearest health facilities in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

	Five nearest health facilities in this village	Average time to travel (minutes)		Primary mode of transportations	
		Throughout the year, except for the disaster times	**During the disaster times**	**Throughout the year, except for the disaster times**	**During the disaster times**
Cyclones					
1	Community clinic	10	20	Walk	Walk
2	Union Health and Family Welfare Centre*	30	50	Walk	Walk/Boat
3	Upazila Health Complex	90	120	Motorbike	Motorbike
4	NGO Health Centre	110	130	Motorbike	Motorbike
5	Private clinic/hospital/doctor	130	150	Motorbike	Motorbike
Floods					
1	Local pharmacy/doctor	10	15	Walk	Boat
2	Community clinic	15	20	Walk	Boat
3	Union Health and Family Welfare Centre**	30	60	Walk	Boat
4	Upazila Health Complex	60	120	Motorbike	Boat
5	Kalmakanda[10]	120	240	Motorbike	Boat

Notes: * Though the community clinic was the closest health facility for the cyclone-hit village dwellers in terms of its distance and time to travel, they typically chose the Union Health and Family Welfare Centre as their nearest hospital-like facility for any consultations.
**Like their counterparts from the cyclone-hit village, people from the flood–hit village typically go to other area's Union Health and Family Welfare Centre for consultations.
Source: Household Survey, 2019–2020.

In the cyclone-hit village of Chadnimukha, the closest available health facility is the community clinic; villagers can access their services on foot in between ten and 20 minutes throughout the year. According to the Family Welfare Assistant (FWA) of the village, the community clinic operates regularly and very effectively. The next-closest health facility for these villagers is the Union Health and Family Welfare Centre, 30 minutes' walk from the village, except during the flooding season, when villagers use either a boat or walk, which takes around 50 minutes. Other health facilities available, listed according to distance from the village, are the Upazila Health Complex (UHC), NGO health centre, and private facilities in Shyamnagar Upazila; these facilities provide primary health care, outpatient care, family planning services, and other preventive health care, which are used less often, particularly when cyclones and their effects increase travel time to as much as 150 minutes.

[10] Kalmakanda is an upazila of Netrokona District in the newly formed Mymensingh Division, Bangladesh.

The flood-hit village of Lamagaon does not have a Union Health and Family Welfare Centre. As identified in Table 4.10, the closest available services are provided by two pharmacies and unqualified doctors in the local market. The villagers also do not have a community clinic in their village; they can go to Mohjompur, the village next door, a 15-minutes walk, for the services provided by the community clinic. For essential treatment, the majority of the villagers of Lamagaon go to the nearest sub-district, Kalmakanda, because the health facilities are better. Respondents reported that the Union Health and Family Welfare Centre of Sreepur South, which had been used by these villagers in the past, was damaged by floods and has been useless for years.

The Health Inspector (HI) and FWA live far from the Lamagaon community clinic, and sometimes, they cannot reach the clinic due to adverse weather conditions. It is also time-consuming for them to travel, either by two-wheeler motorbikes (outside flood season) or by boat (in flood season), to the community clinic from the Tahirpur Upazila. The floodwater comes in May; sometimes, a flash flood happens in early April. The floodwater levels remain high until October, and is typically at exceedingly dangerous levels in June, July, and August.

Overall, the flood-hit village and its upazila have inadequate health facilities. The Upazila Family Planning Assistant stated that:

> *There are Union Health and Family Welfare Centers in 6 out of 7 unions of Tahirpur Upazila. The [UHFW] Centre of Sreepur South Union collapsed ten years ago due to floods. Moreover, there is no Centre in Borodal North. So we have five Centres in the upazila. Out of these five Centres, family planning camps are held in four; no camp is held in the Borodal South due to a lack of human resources. There is no Mother and Child Welfare Centre in our upazila. Pregnant women can give birth only in four centres where their deliveries can be attended by skilled birth attendants (SBA). The road transport systems are poor. There is no ambulance service here, as it is a disaster-prone area. Every year, the water level rises 3 to 4 feet, [flooding the] Balijuri Union Health and Family Welfare Center, and medicines get wasted. (Upazila Family Planning Assistant, Tahirpur Upazila, 2019)*

A key difference between the ability of the villagers from the cyclone-hit and the flood-hit villages to access key health facilities is that, even though Gabura Union, and, therefore, Chadnimukha, is surrounded by water, the road transportation system across the river is sound. As soon as the villagers cross the Kholpetua river, which typically takes 3 minutes, and go through Nildumur ghat [*landing place*], their primary means of transport to Shyamnagar Upazila are motorbikes, easy bikes, and buses. In the flood-hit village, the only mode of transportation on deteriorated roads in winter is a two-wheel motorbike. During the flood season, a boat, either manual or engine-driven, has to take a slow, circular route to reach the hospital at Tahirpur or the nearby Kalmakanda sub-district. During the monsoon season, boats are needed to go in any direction. Consequently, villagers living in the remote areas rely heavily on untrained medical assistants and unqualified so-called 'doctors'.

4.5.3 Family planning facilities and access

The experience of an extreme climate event and its aftereffects can have a significant impact on the use of family planning tools and techniques, and, in turn, fertility rates. Table 4.11 presents the number of women who, at the time of the household questionnaire survey, were using different types of (or no) contraceptives in the study areas. According to the data collected, the percentage of respondents from the cyclone-hit village of Chadnimukha who reported using any contraceptive method was 77.6 percent; in the flood-hit village of Lamagaon, the figure was 68.8 percent. In the cyclone-hit village, 65.8 percent of respondents used modern methods and 11.8 percent used traditional methods. In contrast, 51.9 percent of respondents in the flood-hit village used modern methods and 16.9 percent traditional methods. Comparing their use of methods, it is interesting to note that not only did more respondents in the flood-hit village rely more on traditional methods than those in the cyclone-hit village, but the use of the oral contraceptive pill among respondents from the cyclone-hit village was nearly twice that of those from the flood-hit village. The oral contraceptive pill was by far the most popular modern approach in both villages, followed with a big drop in percentages by injectables and female sterilisation. Withdrawal was one of the most common traditional practices of respondents from both villages, and was notably more widespread among respondents in the flood-hit village (10.8%) than in the cyclone-hit village (6.4%). The least popular methods of contraception in both villages were male sterilisation, IUDs, implants, and condoms. It is important to note that 24.4 percent of respondents in the cyclone-hit village and

31.2 percent in the flood-hit village were not using any method of contraception at the time of the field survey.

Table 4.11 Current use of contraception of currently married women aged 18–49, by contraceptive method in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Methods	***Cyclones* %**	***Floods* %**
Any method (modern or traditional)	77.6	68.8
Any modern method	65.8	51.9
Modern methods		
Oral contraceptive pill	46.6	25.1
Injectables	9.9	12.6
Condoms	0.6	2.6
Female sterilisation	5.1	6.5
Male sterilisation	1.0	0.9
IUD	/	1.7
Implants	0.6	2.6
LAM	1.9	/
Any traditional method	11.8	16.9
Traditional methods		
Rhythm	3.5	3.5
Withdrawal	6.4	10.8
Others (any method)	1.9	2.6
No method (includes pregnant women)	22.4	32.2

Notes: If more than one method was used, only the most effective method was considered in this tabulation; IUD = Intrauterine device; LAM = Lactational amenorrhea method.
Source: Household Survey, 2019–2020.

Respondents to the household questionnaire survey were also asked to identify the most accessible source of modern contraceptives in their area. Table 4.12 shows that contraceptives were more available in the public sector, followed by the private sector. The public sector sites that provide contraceptive tools are community clinics (CCs), union health and family welfare centres (UHFWCs), Upazila (sub–district) Health Complexes (UHCs) and District Health Complexes (DHCs). According to the data collected, neither the respondents nor their partners typically counted on non–governmental organisations (NGOs) or other private sources (e.g., grocery shops) to provide modern contraceptives. Ultimately, the preferred sources of modern contraceptives varied according to their type. To access the pill, most participants (90.6% in the cyclone-hit village of Chadnimukhar and 77.9 percent in the flood-hit village of Lamagaon) visited the community clinic, a location that is the quickest and easiest for them to reach (even in the flood-hit village). Notably, more respondents in the flood-hit village relied on the private sector, using, for example, a local pharmacy to access pills (20.7%) and injectables (43.8%).

This is likely because it is difficult for women in the flood-hit village to travel to the community clinic during the flood season.

Respondents also mentioned that the Family Welfare Assistants (FWAs) frequently could not visit them due to extreme weather conditions and heavy flooding. Community clinics and union health and family welfare centres were the most accessible source for injectables in the cyclone-hit village. In addition, many respondents (17.4%) in the cyclone-hit village reported having visited an NGO health centre to access injectables, while no respondents in the flood-hit village reported having visited an NGO health centre to access any contraceptives. Community clinics were the common source for condoms in both areas. However, a considerable number of women (12.4% in the cyclone-hit village and 18.8% in the flood-hit village) reported that they purchased condoms in grocery shops, likely because these women or their partners depended on condoms during or immediately after extreme events, when public health infrastructure was damaged, or it was difficult to access other familiar sources. For other modern methods such as male or female sterilisation, IUDs, and implants, women visited the Upazila Health Complexes.

Table 4.12 Source of supply of specific modern contraceptive methods [Percent distribution of current users of modern contraceptive methods among women aged 18–49 by the most recent source of a method] in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

	Oral pill		**Injectable**		**Condoms**		**Female sterilisation**		**Male sterilisation**		**IUDs**		**Implants**	
	Cyclones	***Floods***	***Cyclones***	***Floods***	***Cyclones***	***Floods***	***Cyclones***	***Floods***	***Cyclones***	***Floods***	***Cyclones***	***Floods***	***Cyclones***	***Floods***
Public sector	**97.3**	**79.3**	**81.5**	**56.2**	**76.4**	**75**	**100.0**	**100.0**	**100.0**	**100.0**	**0.0**	**100.0**	**100.0**	**100.0**
Community clinic	90.6	77.9	43.5	43.8	69.7	75	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Union Health and Family Welfare Centre	6.7	1.4	30.4	1.5	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25
Upazila (sub–district) Health Complex	0.0	0.0	7.6	10.9	0.0	0.0	100.0	94.4	100.0	100.0	0.0	100.0	100.0	75
District hospital	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Private medical sector	**2.7**	**20.7**	**1.1**	**43.8**	**10.1**	**6.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Private clinic/hospital/doctor	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Local pharmacy	2.7	20.7	0.0	43.8	10.1	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NGO sector	**0.0**	**0.0**	**17.4**	**0.0**	**1.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
NGO health centre	0.0	0.0	17.4	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other private source	**0.0**	**0.0**	**0.0**	**0.0**	**12.4**	**18.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Grocery shops	0.0	0.0	0.0	0.0	12.4	18.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0
Number of women	255	145	92	64	89	16	17	36	3	2	0.0	7	1	8

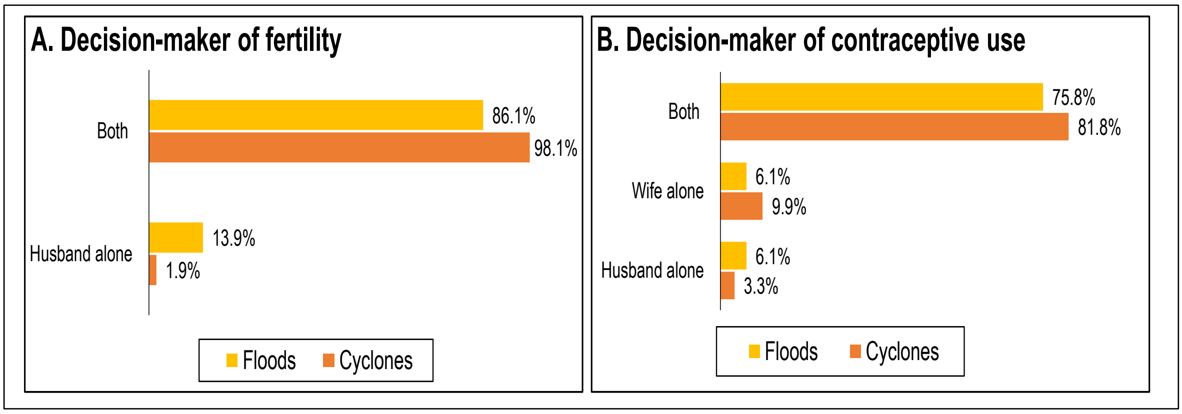
Note: Women or their husbands may use more than one method.

Source: Household Survey, 2019–2020.

4.5.4 Contraceptive use and fertility decision–making

It was found that most couples in both study areas represented in the household survey questionnaire discuss and decide mutually to have a child and make decisions about contraceptive use, as shown in Figure 4.4. For example, the decision to have a child was made mutually by 98.1 percent of respondents in the cyclone-hit village of Chadnimukha and 86.1 percent in the flood-hit village of Lamagaon. The decision to use contraceptives was also made jointly by husband and wife by 81.8 percent of respondents in the cyclone-hit village and 75.8 percent in the flood-hit village. While the differences are not large, it is worth highlighting that more respondents from the cyclone-hit village participated in these decision-making processes than their counterparts in the flood-hit village.

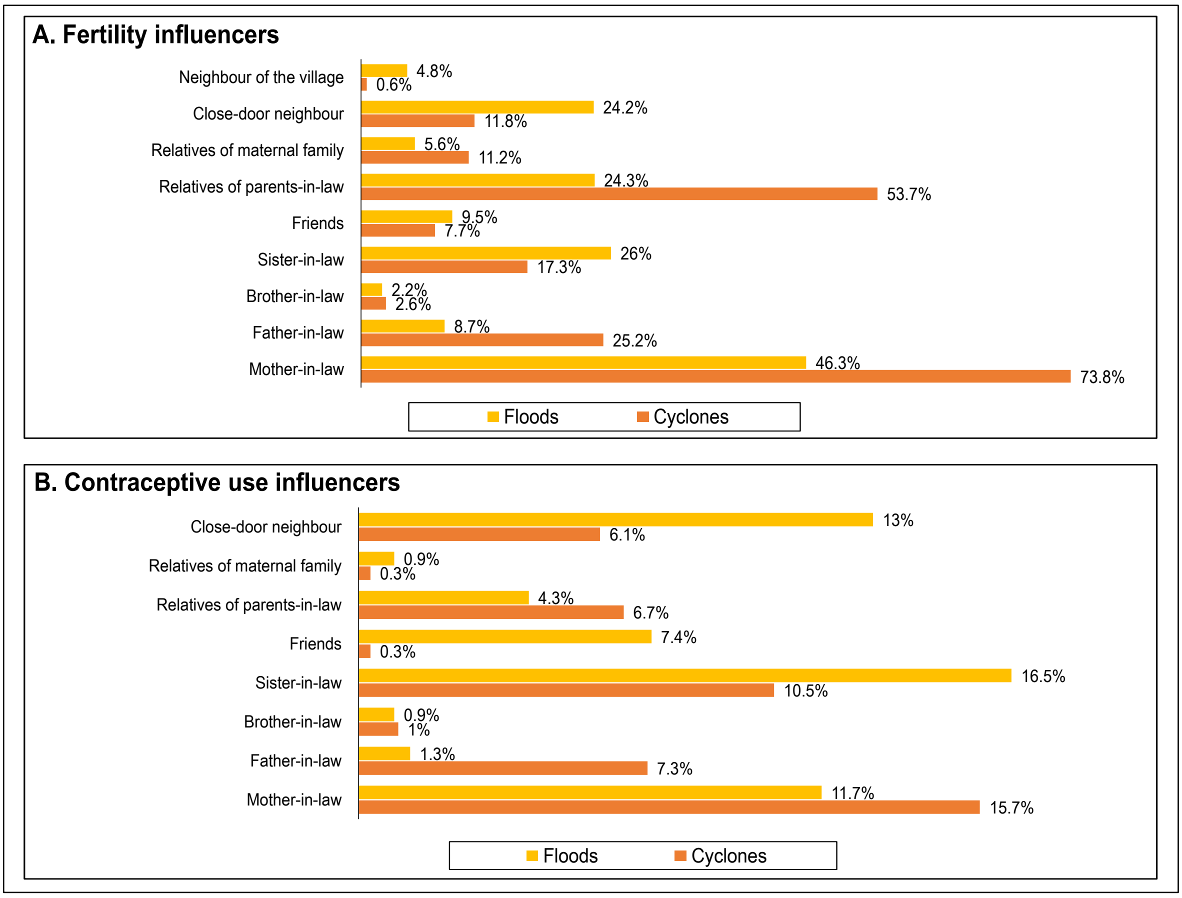
Figure 4.4 Decision maker of fertility and contraceptive use in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).



Source: Household Survey, 2019–2020.

It is important to note that, in typical rural villages in Bangladesh, decisions to have a child or use contraceptives can be influenced by other members in the household as well as relatives and friends. According to the results presented in Figures 4.5 A and B, people outside the immediate family had a greater influence on decisions to have a child than on decisions to use contraceptives. Figure 4.5 A reveals that mothers-in-law, relatives of the parents-in-law, sisters-in-law, and next-door neighbours were more likely to influence the decision to have a child in both study villages. The influence of the mother-in-law (73.8%) and the relatives of parents-in-law (53.7%) had a greater influence on that decision for respondents in the cyclone-hit village than was the case for those from the flood-hit village (46.3% and 24.3%, respectively). Notably, a quite high percentage of respondents from the flood-hit village identified their close neighbours (24.2%) and neighbours of the village (4.8%) among the people who could influence their decision to have a child.

Figure 4.5 Persons influencing fertility and contraceptive use in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).



Source: Household Survey, 2019–2020.

Regarding contraceptive use, the mothers-in-law, sisters-in-law, and close neighbours significantly influenced the contraceptive use of the respondents from both study villages, as shown in Figure 4.5 B. Of the possible influencers, mothers-in-law (15.7%) and sisters-in-law (10.5%) had the greatest influence on the contraceptive use of respondents in the cyclone–hit village. Similarly, in the flood-hit village, sisters-in-law (16.5%) and mothers-in-law (11.7%) were quite strong influencers, and close neighbours (13%) also had a significant influence on the respondents' use of contraceptives.

It is important to note that government and non-government organisations have a significant role to play in these decisions, as well: these organisations can raise awareness among women about contraceptive use and mother-and-child health, empower them through financial activities, facilitate their contribution to food security through homestead gardening, and enhance the well-being of households. During fieldwork, it was observed that some NGOs were actively engaged in supporting the reproductive health of women, particularly in the cyclone-hit village of Chadnimukha. An internationally reputed NGO (World Vision) was actively functioning in the cyclone-hit village, focusing on a project called *Nobo Jatra* (which means *New Beginning*), which addressed women's reproductive health and child nutrition. The Nobo Jatra initiative, led by World Vision Bangladesh and in collaboration with the Ministry of Disaster Management and Relief (MoDMR) of the Government of Bangladesh, collaborated with the World Food Program and Winrock International. Nobo Jatra provided assistance to pregnant and nursing mothers who were below the lower poverty line and faced chronic food insecurity. Selected individuals were enrolled in a 15-month nutritional security net program and received BDT 2240 (USD 27.5) each month. The 15-month window for cash transfers had been identified to coincide with the period beginning in the second and third trimesters of pregnancy and ending when the child is 9 months old to cover the most critical transition period, from exclusive breastfeeding to the consumption of a combination of breast milk and formula. The program aimed to enhance women's involvement in nutrition and health decision making by helping to improve women's capacity to accept cash, open savings accounts, and manage their mobile banking information, as well as improving government frontline staff's responsibility to assess participants' gender sensitivity, nutrition and health status, and decision-making skills.

4.6 Conclusion

This chapter has provided an overview of the study villages and how the selected villages were vulnerable to extreme climate events and are vulnerable to various climatic disasters to different degrees. Differences in demographic, economic, and social characteristics of women and their households were outlined and discussed that is helpful to understand the differences in fertility rates between areas. This research goes far beyond that considering the unexplored factor of extreme climate events to understand how they can influence women to have another child.

Understanding the fertility dynamics of women requires an overview of the health facilities and family planning programs in each of the villages. Therefore, this chapter demonstrated the health facilities, women’s general health, contraceptive use, and the source and supply of modern contraceptives. The findings showed that more women in the flood–hit village relied on traditional methods to control fertility, suggesting that family planning practitioners should promote the facilities and raise awareness among women. Access to healthcare after a climatic event was also found to be worse because of a lack of convenient transport and lack of available local healthcare facilities, and it was different for villages hit by cyclones and floods.

Women living in areas affected by extreme climate events are likely to develop and suffer from both physical and mental health complexities, affecting adversely their reproductive health. The adverse effects of cyclones or floods have a different impact on women’s reproductive health, affecting their fertility outcomes and intentions. Moreover, the resulting poor socio–economic conditions (e.g., loss of income, crop production, and land) due to the irreversible impacts of climatic events can increase the food insecurity and limit the budget allocation for women’s health. The study’s findings can inform policy recommendations concerning fruitful disaster risk reduction and family planning programs during climatic events.

Chapter 5 Is a Cyclone-Prone Area More Vulnerable than those in a Flood-Prone Area? Towards a Climate Vulnerability Index for Rural Households in Bangladesh

5.1 Introduction

Having a sophisticated understanding of the vulnerability of rural households to climate change and extreme events plays a critical role in the formulation of effective disaster risk reduction strategies and can help inform the development of climate change adaptation and mitigation approaches. Though the frequency and intensity of extreme climatic events are increasing, both the experience and the adverse effects of such extreme events are unevenly distributed at individual, household, community, national, and global levels, and the impact of such catastrophic events on the loss and damage experienced by households differs by the type of event. This chapter addresses the question of whether rural households in a cyclone-prone area were more vulnerable than those in a flood-prone area in Bangladesh.

Evaluating climate change vulnerability in specific geographical areas can support the development and improvement of adaptation measures. This chapter begins with an examination of changes in climatic variabilities (e.g., temperature and rainfall) in the study districts and integrates how women perceive these changes with the meteorological records and the perceptions of their male counterparts. Given uneven regional variation in household sensitivity to climate threats and the expectation that households in cyclone-prone areas will be more susceptible than those in flood-prone areas, this chapter employs a climate vulnerability index (CVI) to precisely assess the exposure of households to climate change and extreme events in order to determine which communities are more susceptible. This index is based on detailed data collected from the household surveys conducted with women from Chadnimukha and Lamagaon. Where necessary, the male household heads and/or senior members of households provided additional information during the survey process.

5.2 Trends of climatic indices (temperature and rainfall), 1980–2015

To provide a basis for comparison between perceptions and climate records for the selected districts of Satkhira (including Chadnimukha) and Sunamganj (including Lamagaon), data on climate variability with respect to temperature and rainfall (1980–2015) were collected from the Bangladesh Meteorological Department. Because there is no weather station in Sunamganj, the meteorological data of the nearby station monitoring Sylhet was used to report the changes in the Sunamganj district.

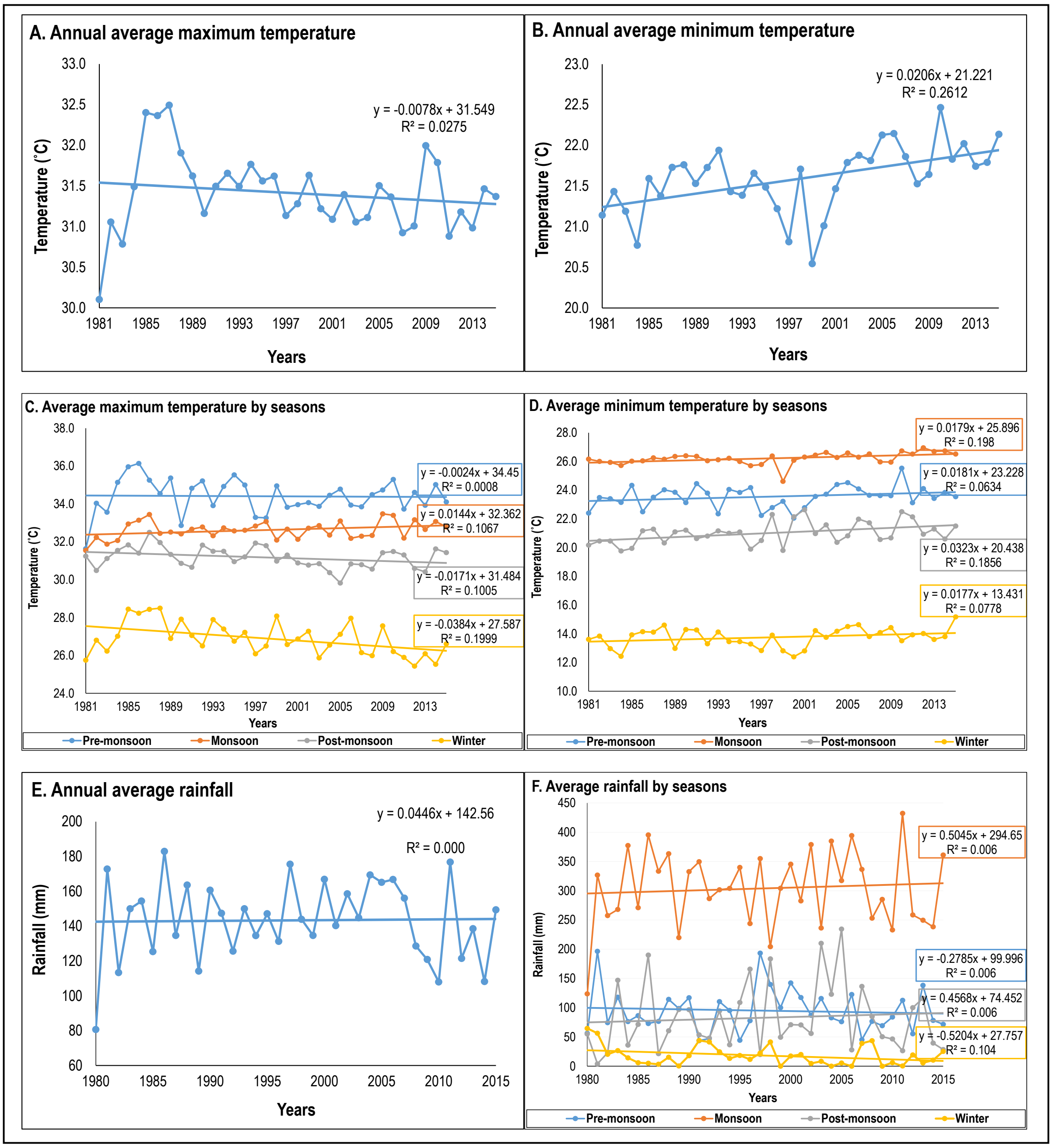
The reported trends of average minimum and maximum temperatures and average rainfall, including seasonal variations, for the districts of Satkhira and Sylhet from 1980 to 2015 are shown in Figures 5.1 and 5.2. Sen's slope estimations (Q) for the magnitude of the trends and the level of significance in Sylhet and Satkhira districts are presented in Table 5.1. The records show that maximum and minimum temperature trends have been more pronounced in the Sylhet district than in Satkhira during the study period. The increase in maximum and minimum temperatures in flood-prone Sylhet, annually, pre-monsoon, monsoon, post-monsoon, and in winter, was highly consistent. Despite the apparent volatility of the changes in maximum temperatures in cyclone-prone Satkhira, the annual average minimum temperature change in this district, across all seasons, increased consistently and indicates a rise in average temperatures in Satkhira.

According to the Sen's slope results presented in Table 5.1, there was a consistent decrease in the average maximum temperature in Satkhira, both annually and for most seasons except monsoon season. The decreasing trend in maximum temperatures experienced by Satkhira district was significant for the post-monsoon and winter seasons. However, the linear estimation of the average maximum of monsoon temperature in Satkhira, the only season that recorded an increase, shows that it rose at a rate of 0.014 ˚C per year (see Figure 5.1C). In contrast, the average minimum temperatures consistently climbed in this district. The magnitude of the minimum and maximum temperature trends of each season—annual (MK, Q= 0.020 ˚C, –0.012 ˚C), pre-monsoon (MK, Q = 0.013 ˚C, –0.010 ˚C), monsoon (MK, Q = 0.018 ˚C, 0.017 ˚C), post-monsoon (MK, Q = 0.031 ˚C, –0.018 ˚C), and winter (MK, Q= 0.017 ˚C, –0.044 ˚C)—in Satkhira district show noticeable variations (Table 5.1).

In the Sylhet district, the Sen's slope results show the average maximum and minimum temperature changes exhibited significant upward trends both annually and seasonally (Figure 5.2). The extent of these trends suggests that the increase was more highly pronounced for the maximum temperatures—annual (MK, Q= 0.054 ˚C), pre-monsoon (MK, Q = 0.067 ˚C), monsoon (MK, Q = 0.050 ˚C), post-monsoon (MK, Q = 0.055 ˚C), and winter (MK, Q= 0.044

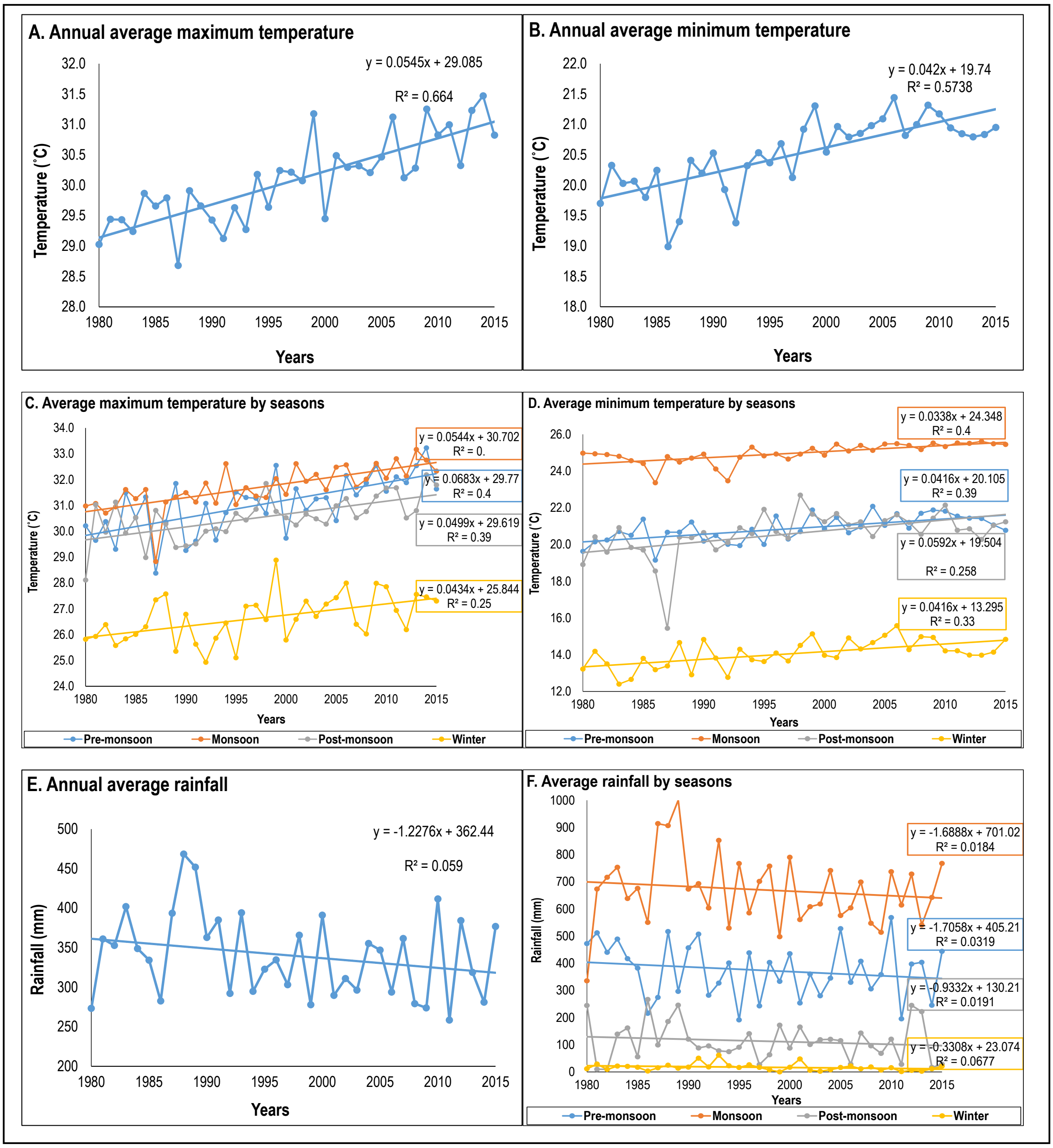
˚C)—than the minimum—annual (MK, Q= 0.037 ˚C), pre-monsoon (MK, Q = 0.044 ˚C), monsoon (MK, Q = 0.030 ˚C), post-monsoon (MK, Q = 0.047 ˚C), and winter (MK, Q= 0.041 ˚C) (see Table 5.1).

Figure 5.1 Trends of average maximum and minimum temperature and average rainfall in Satkhira districts (including cyclone-hit Chadnimukha), 1980–2015.



Data source: Bangladesh Meteorological Department (2020).

Figure 5.2 Trends of average maximum and minimum temperature and average rainfall in Sylhet districts (Lamagaon as a neighbouring village, hit by floods), 1980–2015.



Source: Bangladesh Meteorological Department (2020).

Table 5.1 Results of Sen's slope value during the period of 1980–2015 in cyclone-hit Satkhira and flood-hit Sylhet districts.

Temperature and rainfall	Sen's slope (Q)	
	Cyclone-prone Satkhira	Flood-prone Sylhet
Seasonal temperature output (°C)		
Average maximum of		
Annual	–0.012	0.054***
Pre–monsoon	–0.010	0.067***
Monsoon	0.017+	0.050***
Post–monsoon	–0.018+	0.055***
Winter	–0.044**	0.044**
Average minimum of		
Annual	0.020***	0.037***
Pre–monsoon	0.013	0.044***
Monsoon	0.018***	0.030***
Post–monsoon	0.031*	0.047***
Winter	0.017	0.041***
Seasonal average rainfall output (mm)		
Annual	–0.102	–1.345
Pre–monsoon	–0.082	–2.118
Monsoon	0.172	–2.062
Post–monsoon	0.316	–1.044
Winter	–0.413+	–0.274+

Note: ******* Significant trend at 0.001 level of significance
****** Significant trend at 0.01 level of significance
***** Significant trend at the 0.05 level of significance
+ Significant trend at the 0.1 level of significance
Data source: Bangladesh Meteorological Department (2020).

Though the rainfall data shows anomalies in Satkhira, the decrease experienced in Sylhet district was consistent, and, according to Sen's slope results for both Satkhira and Sylhet, the change was only significant for the winter rainfall, which indicates that both districts have experienced extreme prolonged dry spells in the winter months. While the overall annual trend in rainfall behaviour in Satkhira was downwards, the trends across different seasons varied, with falls in the pre-monsoon and winter seasons, and rises in the monsoon and post-monsoon seasons. The magnitude of the drop in winter rainfall in this district (MK, Q = –0.413 mm per year) was the highest (at 0.520 mm per year) of all the seasons; there was an increased rainfall deficit in the Satkhira district for the months between December and May. The rise in the average rainfall in monsoon and post-monsoon seasons could be associated with the storm-induced floods and the riverbank erosion experienced in the selected cyclone-affected village of Chadnimukha, as significant rainfall increases the water level of the nearby rivers affected by tidal waves.

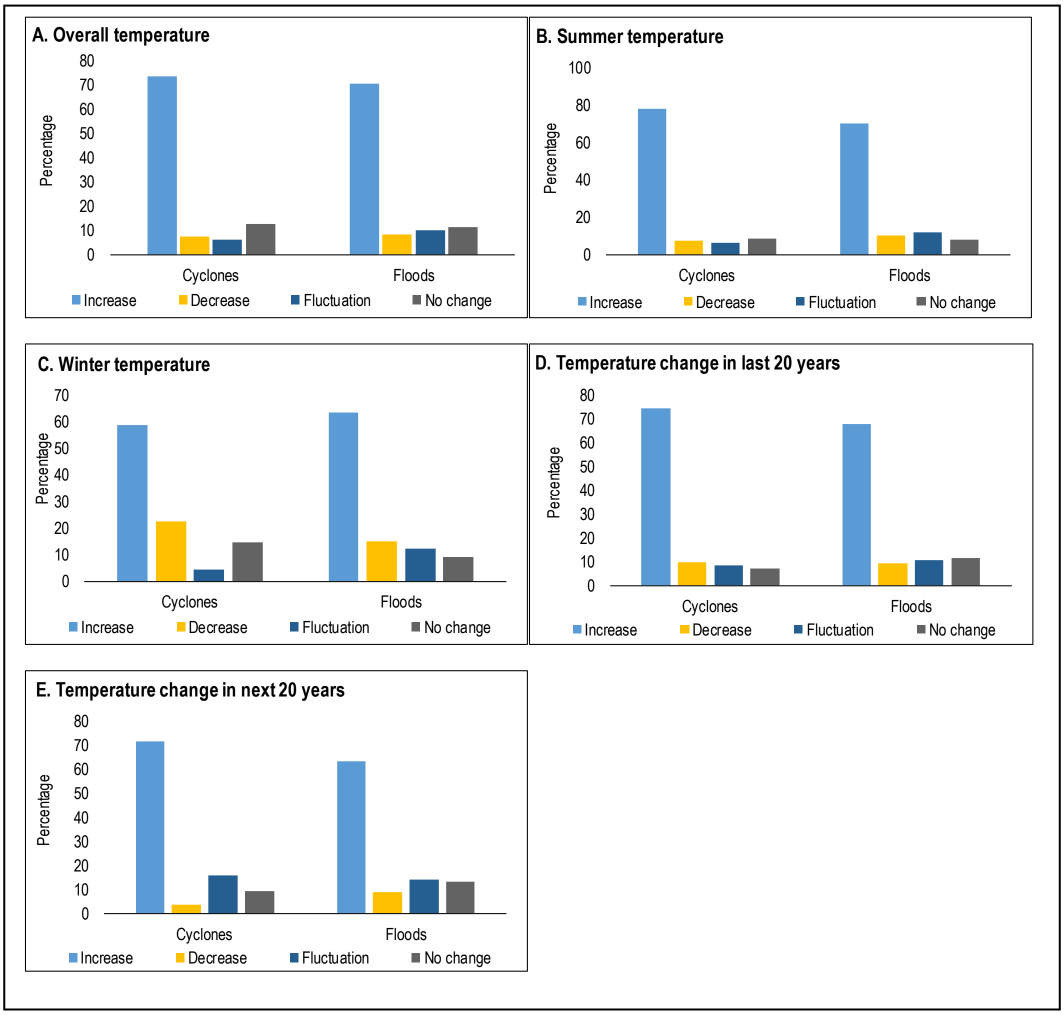
According to the Sen's slope results for the Sylhet district, rainfall decreased consistently at a level which would have had a significant impact on agriculture and other potential livelihood options of dwellers. The total annual rainfall in the Sylhet district fell by 1.22 mm per year; seasonally, it decreased by 1.70 mm, 1.68 mm, 0.93 mm, and 0.33 mm per year in pre-monsoon, monsoon, post-monsoon, and winter, respectively. The magnitude suggests that the decline in rainfall was the highest in the pre-monsoon months (MK, Q = –2.118 mm/year), followed by monsoon (MK, Q = –2.062 mm/year), post-monsoon (MK, Q = –1.044 mm/year), and winter (MK, Q = –0.274 mm/year).

5.3 Women's perceptions of climate change variability in flood- and cyclone-affected areas: Is it consistent with meteorological records and men's perceptions?

As part of the household survey, women from both villages were asked to share their perceptions of the overall temperatures, rainfall, and typical seasons in their village, including their observations of any past and future changes. Data collected from their responses are presented in Figures 5.3, 5.4, and 5.5.

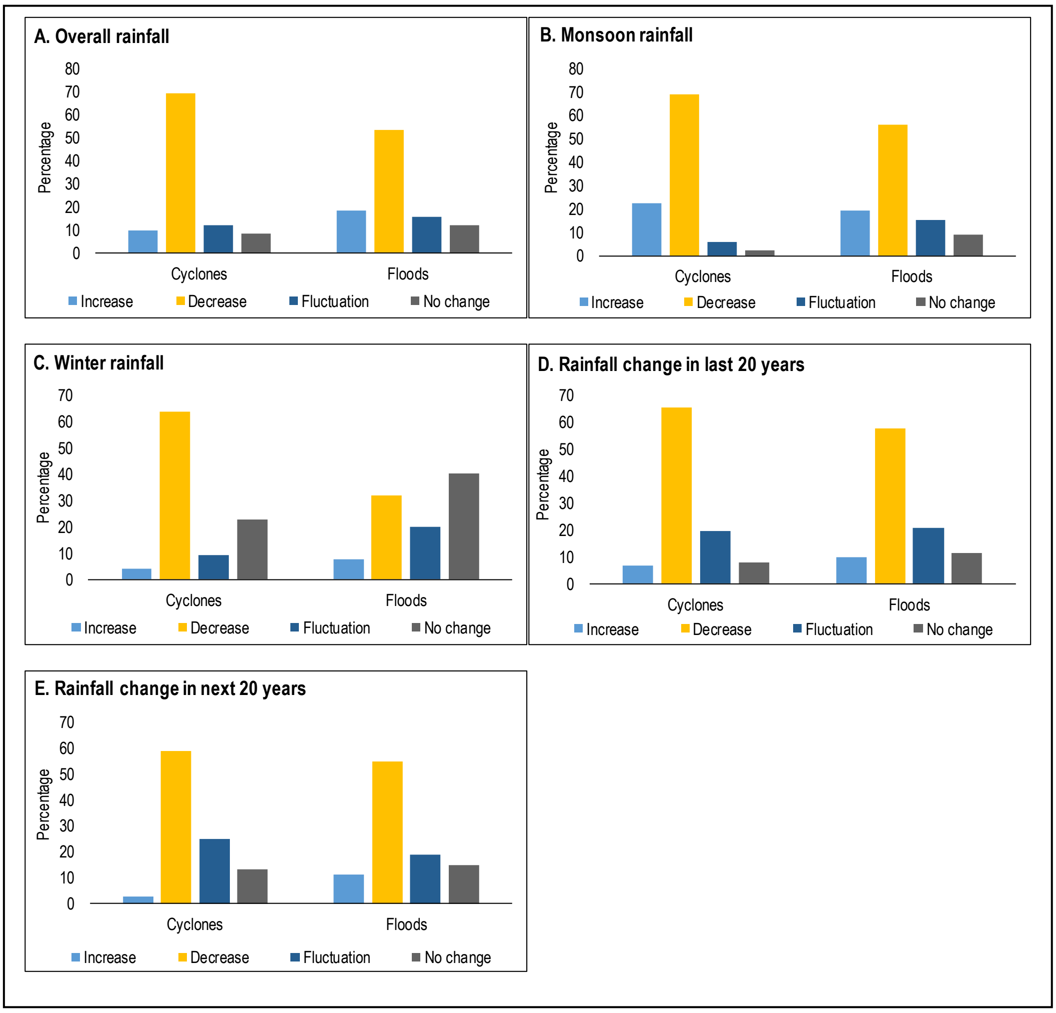
As regards temperature, Figure 5.3 shows that most participating women from both areas reported, at very similar rates, increases in temperature over the last 20 years. They also expect that temperatures will continue to rise. As shown earlier in Figures 5.1 and 5.2, the meteorological data confirms that temperatures–except maximum temperature in Satkhira–are increasing across different seasons. This is also confirmed by long-term (1950-2010) meteorological data of minimum and maximum temperatures observed in Satkhira and Sylhet districts (see Figure 5.6) (Khatun et al., 2016). Several weather data investigations have made projections that predict a rise in Bangladesh's mean temperature by 0.8 ℃ by 2030 (McSweeney et al., 2010), 2.5 ℃ by 2075 (Rahman et al., 2012a), and 3.0 to 3.5 ℃ by 2100 (Met Office, 2011).

Figure 5.3 Perceptions of women respondents about (A) overall temperature, (B) summer temperature, (C) winter temperature, temperature changes in (D) the last 20 years and (E) the next 20 years, in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).



Source: Household Survey, 2019–2020.

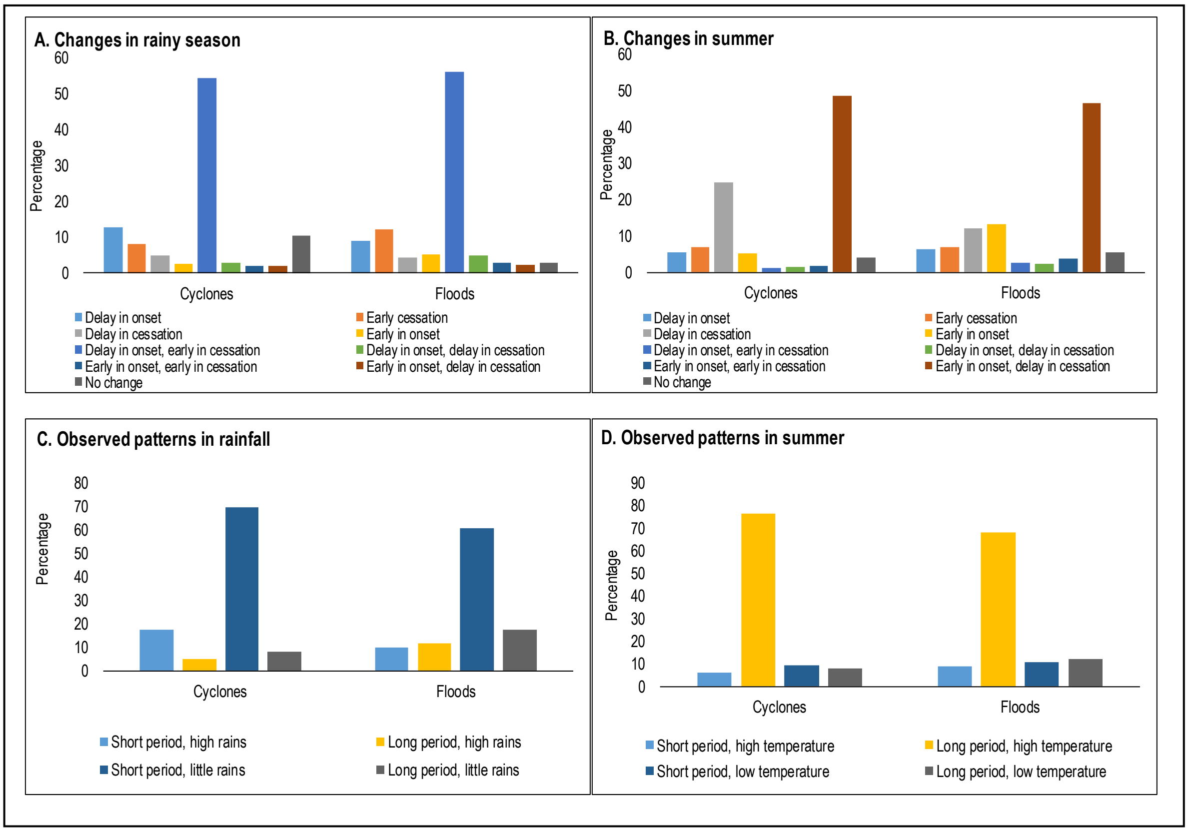
Figure 5.4 Perceptions of women respondents about (A) overall rainfall, (B) monsoon rainfall, (C) winter rainfall; rainfall changes in (D) the last 20 years and (E) the next 20 years, in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).



Source: Household Survey, 2019–2020.

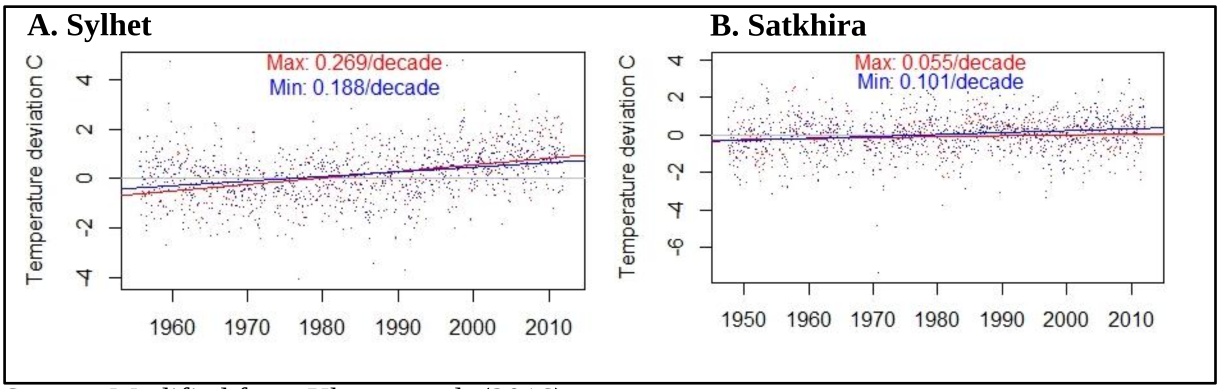
Similarly, most of the women reported having observed an increase in summer and winter temperatures. For example, an increase in summer temperature was observed by 78.3 percent of surveyed women in cyclone-affected areas and 70.1 percent in flood-affected areas and increased winter temperature by 58.8 percent and 63.6 percent of women, respectively (as shown earlier in Figure 5.3). The meteorological data also confirm that the respondents have an accurate perception of changing temperatures recorded in the winter season as well as in other seasons now regarded as summer. The meteorological data of Satkhira from 1980 to 2015 showed a slight non-significant fall in the annual average maximum temperature, while the increase in the average minimum of annual temperature, including during monsoon and post-monsoon seasons, was significant (see Figure 5.1 A, B, C, D). The rise in both maximum and minimum temperatures annually and across all seasons in Sylhet district was more pronounced (Figure 5.2 A, B, C, D). Simultaneously, the long-term minimum and maximum temperature data showed an upward trend (see Figure 5.6 A, B).

Figure 5.5 Perceptions of women respondents about changes in (A) the rainy season and (B) summer/observed patterns in (C) rainfall and (D) summer, in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).



Source: Household Survey, 2019–2020.

Figure 5.6 Maximum and minimum temperature trends over flood-hit Sylhet and cyclone-hit Satkhira districts, 1950-2010.



Source: Modified from Khatun et al. (2016).

The male participants in the focus group discussions held in both villages also reported the existence of only two noticeable seasons in Bangladesh: winter and summer, in which the summer season includes the rainy season.

A male farmer during a focus group discussion held in the flood-hit village described the changes in temperature experienced in Lamagaon:

> *The temperature of the wetland area is increasing day by day. Over the past 20 years, the temperature has increased dramatically, affecting people's everyday lives. The temperature was average before 2010. Now, it is increasing rapidly, and the heat is not tolerable. Moreover, the hot days sometimes start from* Falgun *[around 15 March in the Bengali calendar].* Magh *[February] is still winter. The temperature remains maximum from* Choitra *to* Ashar *[mid-April to mid-July]. (Participant 9, FGD, flood–hit village of Lamagaon)*

During one focus group discussion held in the cyclone-hit village, a 45-year-old fisherman shared the following about high temperatures:

> *Compared to what I have seen in my childhood, the temperature of recent years is very high. When we were children, we used* tal pakha *[a hand fan made of dry palm leaves] or a folded* gamcha *[a traditional thin, coarse cotton towel] to wave for cool air when summer temperatures were extreme. The airflow from the tal pakha or gamcha was enough to cool our bodies. Now, the situation has changed significantly. Every household in our village has a solar panel to operate an electric ceiling or pedestal fan. This means people feel hot weather throughout the year. (Participant 16, FGD, cyclone-hit village of Chadnimukha)*

A male high school teacher aged 45 years added that Chadnimukha had also become warmer in winter:

> *We do not feel extremely cold in recent winter months compared to the past 15 to 20 years. For present days in winter, a thin quilted blanket of 500 grams is enough for the winter season. It was different in the past. We used a double layer blanket of 5 to 6 kilos*

to keep our bodies warm on cold days. In the past, we have seen that people from foreign countries, especially the Middle East, used to bring a heavy blanket for their family [when they came to Bangladesh], now they do not. Can you imagine the changes? (Participant 17, FGD, cyclone-hit village of Chadnimukha)

As illustrated in Figures 5.4 A and B, most household survey participants reported decreases in the overall rainfall and in the rain experienced during the monsoon season. In the flood-affected area, perceptions of winter rainfall (Figure 5.4 C) were randomly distributed: 32 percent perceived an increase, and 40 percent reported no change. In contrast, 64 percent of women in the cyclone-affected area perceived rainfall as having declined. Although a considerable number of household survey respondents from both areas reported and predicted fluctuations in rainfall (Figure 5.4, D, E), the majority perceived a downward trend in rainfall over the last 20 years, which they believe will continue.

The meteorological records of rainfall showed decreasing trends with some erratic behaviour recorded for monsoon and post-monsoon rainfall in Satkhira (Figure 5.1, E, F). However, the perception among household survey respondents of monsoon rainfall was inconsistent with the meteorological records in Satkhira. The women surveyed from Chadnimukha perceived it as decreasing, but the meteorological records reveal upward trends. The perceptions of the women from Lamagaon were consistent with meteorological records that indicate that the amount of rainfall was consistently declining in the Sylhet region (Figure 5.2, E, F). It has been found that the amount of monthly rainfall in Bangladesh between 1981 and 2010 (in reference to 1971-2000) declined for five months (February, April, May, August, and November), increased for three months (July, September, and October), and remained almost unchanged for the remaining months (Khatun et al., 2016). It has also been projected that the total annual rainfall of Bangladesh will decrease by 2 mm by 2030 (McSweeney et al., 2010) and by 12 mm by 2050 (Rahman et al., 2012b).

Findings from focus group discussions are consistent with the descriptive statistics and meteorological records of rainfall. One male participant, an entrepreneur, described changes in rainfall in Lamagaon:

Compared to the past, the amount of rainfall is deficient and decreasing. The amount of rainfall has been meagre in recent decades. Twenty years before, the amount of rainfall was extreme for three months in the monsoon season (June to September). Recently, it has decreased dramatically throughout the year. Also, except for the rainy season, the rains that used to occur in other months have disappeared. (Participant 18, FGD, flood-hit village of Lamagaon)

A 40-year-old male farmer from Chadnimukha said:

It the past, there were rains for a consecutive seven or eight days during rainy seasons. We could not go outside of our homes during these rainy days. Now, we do not see the days of extreme rains. The timing and amount of rainfall has changed a lot. For example, in Ashar *(June–July), we usually plant Boro rice. Let us look at 2019. It is now* Shrabon *(July–August); we are still waiting to harvest the Boro. It was* Borsha *[normal flood] time in* Ashar *in the past; now it is not. (Participant 19, FGD, cyclone-hit village of Chadnimukha)*

Women's perceptions of the changes to the summer and rainy seasons in the last 20 years are shown in Figure 5.5. Regarding the rainy season, more than half of the women in both areas perceived the season to have been delayed in onset and early in cessation. About the changes in the summer season, almost half of the respondents in both areas perceived this season now has an early onset but delayed cessation. This means the women in the study areas are now experiencing a longer summer and a shorter rainy season (Figure 5.5, A, B). This finding is consistent with perceptions of farmers in Sylhet recorded in a previous study (Kamruzzaman, 2015). When the women were asked in the household survey about the rainfall patterns in their villages in the rainy seasons, most of them reported that the rainy season now comes for a short period with little rain. Their observed patterns in the summer are that summers are long in both areas and feature high temperatures (Figure 5.5, C, D). These perceptions are also consistent with the findings of Kamruzzaman (2015).

Male participants in focus group discussions also perceived similar changes in the seasons. A few excerpts of focus group discussions that provide examples are as follows:

Bangladesh used to be a country of six seasons with two months for each season. Of the twelve months, at present, there are eight months when the temperature remains high and can be regarded as summer. Of the remaining four months, two are rainy seasons and two are winter. Moreover, the timing of the seasons has changed, either it is early or there are delays to the start and end. In the past, we saw borsha *[regular floods] in* Jaishtha *month [May–June]; now, we cannot see them even in* Ashar *month [June–July]. (Participant 20, FGD, cyclone-hit village of Chadnimukha)*

We would call the Vhadro *month (August–September)* Pocha Vahdro *[putrid month]. We called it this because there was an odour from the mud during this month because there was always rain. Due to the heavy rain, the soil decomposes [and generates an] odour. We now can say there are rains, though they are little in amount and decreased in trend, in* Ashar *and* Shrabon *months (June–August). There is, however, no continuous rainfall like before [so there is no* Pocha Vahdro *month]. (Participant 16, FGD, cyclone-hit village of Chadnimukha)*

It was found that participants from both study districts had witnessed significant changes in climate variabilities, which must have affected all aspects of their lives, including their agriculture, livelihood, food security, and health. It is reasonable to expect that the impact was felt, to some degree, by all of the households and communities of the districts. To identify the extent of the impact, the following section assesses the vulnerability of households in the study area to climate change and extreme events through an established index.

5.4 Assessing the vulnerability of households to climate change and extreme events using a Climate Vulnerability Index (CVI)

The 2007 IPCC Fourth Assessment Report defines *vulnerability* to climate change and extreme events as a product of three dimensions: exposure, sensitivity, and adaptive capacity (IPCC, 2007). However, the dimension indicating exposure (to hazards) is not considered in the IPCC Fifth and Sixth Assessment Reports for assessing vulnerabilities (IPCC, 2014, 2022). These parameters are considered dynamic (Smit & Wandel, 2006), indicating that vulnerabilities can vary within communities and across societies, regions, and countries, and change over time. According to IPCC (2007), vulnerability can be described by the equation below:

Vulnerability = exposure + sensitivity – adaptive capacity

The nexus among these three distinct endogenous dimensions is unsteady and shifts depending on the circumstance. Dimensions are endogenous in the sense that they are distinctive to each situation and are impacted by other external variables. For example, a community's exposure, sensitivity, and ability to adapt are likely to differ depending on the kind of climatic event experienced (e.g., cyclones or floods) and its severity. Exposure and sensitivity to extreme climate events increase vulnerabilities, while the ability to adapt in the face of such events decreases vulnerability (Ford & Smit, 2004).

The assessment of vulnerability highlights social processes and systemic components in order to determine climate-vulnerable components (Ford et al., 2010). According to the IPCC Sixth Assessment Report, the primary goal of vulnerability assessment is to identify and then address the underpinning issues contributing to present vulnerabilities (IPCC, 2022). The Climate Vulnerability Index (CVI) devised by Pandey and Jha (2012) has been successfully used to assess climate change risks and hazards to rural riparian families in Bangladesh (see Alam, 2017) and is used in this study to assess the vulnerability of the rural households in the two study areas to climate change and extreme events.

The CVI takes eight primary components about an individual or group into consideration when assessing vulnerability: socio-demographic profile, health, food, water, livelihood strategy, social networks, climatic variability, and natural disasters. Each primary component of the CVI has its own set of sub-components. Table 5.2 depicts the eight primary components and 42 sub-components used to determine vulnerability scores.

The CVI addresses aspects of the vulnerability equation introduced above through its eight main components. A community's *adaptive capacity* can be predicted based on its socio-demographic condition, livelihood processes, and social networks. Its *sensitivity* is related to its water and food sources as well as the overall health of the population. The frequency and severity of climatic events experienced by a community define its *exposure* (Alam, 2017; Pandey & Jha, 2012; Han et al., 2009; IPCC, 2007, 2014). If information associated with these relevant components can be found and described for a given area, the scores generated by the Climate Vulnerability Index are likely to be applicable to other comparable circumstances

(Pandey & Jha, 2012). Because the CVI is quite flexible, this research has incorporated (or eliminated) relevant sub-components based on fundamental evaluations of literature on the subject, local field site visits, and constructive conversations involving communities and professionals.

The CVI, an extremely valuable tool for contrasting intra-and inter-group vulnerabilities and identifying groups of the least and most vulnerable, employs a framework for grouping and combining geographical, economic, and social sub-components that may be utilised for development and adaptation planning. This study embraced empirical survey data collected from 544 households (313 from cyclone- and 231 from flood-hit villages) to construct a CVI to measure their climate vulnerability. The results of the index are best understood by "0" (least vulnerable) and "1" (most vulnerable). It is important to note that systematic approaches to the assessment of the vulnerabilities of households or communities are subjective instead of objective; the conclusions should be determined and considered with discretion.

The CVI for this study has been computed by using a widely recognised balanced weighting approach (Hahn et al., 2009; Pandey & Jha, 2012). Although each primary component of the CVI is made up of numerous sub-components, it is believed that each sub-component can contribute equally to the whole index. Indexing techniques were employed to turn immeasurable qualities–such as the type of house, livelihood activities, and perceptions of climate variability–into measurable ones. Because the scales that are typically used to measure each component vary, when the CVI is developed, each sub-component is first standardised by an index (Hahn et al., 2009).

In the context of this study, Equation 1 has been utilised to form the index measurement for each sub-component of its primary component, where S_v is the sub-component value for v village. S_{min} and S_{max} is the minimum and maximum value of sub-component:

$$Index_{sv} = \frac{S_v - S_{min}}{S_{max} - S_{min}} \quad (1)$$

Each sub-component was transformed into a standardised index value employing the minimum and maximum values of the sub-components. The minimum and maximum values for variables measuring frequencies were set at "0" and "100".

Following the standardisation of the values of the sub-components, each major component was calculated using Equation 2, where M_v is one of the major components of the CVI. $Index_{svi}$ is the value of a sub-component, belonging to major component [M_v] for avillage, and n is the number of sub-components in the major component:

$$M_v = \frac{\sum_{i=1}^{n} Index_{svi}}{n} \tag{2}$$

After calculating values for each of the eight primary components, an index score was calculated for each of the dimensions of exposure, sensitivity, and adaptive capacity. The index for *exposure* (Exp) consists of natural disaster (ND) and climate variability (CV), which was calculated using Equation 3, where W_{e1} and W_{e2} are the weightings for the components of natural disaster (ND) and climate variability (CV) based on the number of sub-components of each component. For example, the component *natural disaster* has five sub-components, and *climate variability* has seven:

$$Exp = \frac{W_{e1}ND + W_{e2}CV}{W_{e1} + W_{e2}} \tag{3}$$

The index for *sensitivity* (Sen) was calculated using Equation 4, where, W_{s1}, W_{s2}, and W_{s3} are the weightings for major components of health (H), food (F), and water (W), based on the number of sub-components under each component:

$$Sen = \frac{W_{s1}H + W_{s2}F + W_{s3}W}{W_{s1} + W_{s2} + W_{s3}} \tag{4}$$

The index for *adaptive capacity* (Ada. Cap) was calculated using Equation 5, where, W_{a1}, W_{a2}, and W_{a3} are the weightings for the major components of sociodemographic profile (SD), livelihood strategies (LS), and social networks (SN), based on the number of sub–components under each component:

$$Ada.Cap = \frac{W_{a1}SD + W_{a2}LS + W_{a3}SN}{W_{a1} + W_{a2} + W_{a3}} \tag{5}$$

The index value of the exposure, sensitivity, and adaptive capacity dimensions were collated to calculate the CVI using Equation 6, where N_1 indicates the number of primary components in a dimension. The score for each dimension will achieve a minimum of 0 and a maximum of 1.

$$CVI = 1 - \left|\left\{\frac{N_1 Exp - N_2\, Ada.Cap}{(N_1 + N_2)}\right\}\right| * \left\{\frac{1}{Sen}\right\} \tag{6}$$

Table 5.2 Primary components and sub-components of the climate vulnerability index (CVI).

Primary component	Sub-components	Explanation of sub-components	Associated survey questions	Assumed relationship between (sub)component and vulnerability
Socio-demographic profile	Family dependency index	Population ratio of those aged under 15 and aged above 65 years to the working-age population (over 15 to below 65)	How old are the members of your family?	A higher dependency ratio increases vulnerability.
	Percentage of households in which the head has not attended school	Percentage of households where the head of the household has no schooling	How many years of schooling has the head of the family completed?	The higher education level of the head of household decreases vulnerability.
	Family size	Family size of a household	How many people are in your family?	Larger family size is associated with increased vulnerability.
	House type diversity index	Percentage of households with *kutcha* (houses made of wood, mud, straw, and dry leaves)	What type of house do you live in?	*Kutcha* structures are more likely to be highly sensitive to extreme climate events.
Livelihood strategies	Average agricultural livelihood diversification index	The inverse of (the number of agricultural livelihood activities + 1) of livelihood activities; e.g. a household that farms, raises animals, and collects natural resources will have a livelihood diversification index of 1/(3+1)=0.25	What do the people in your family do to earn a living?	A higher number of livelihood options reduces vulnerability.
	Percentage of households dependent solely on agriculture as a source of income	Percentage of households dependent solely on agriculture as a source of income	Is agriculture the main source of income in your household?	Dependency on climate-sensitive agriculture increases vulnerability.
	Percentage of households whose members migrate for work	Percentage of households in which male members of the household migrate for work	Does anyone in your household migrate to work? Who? For how many days a year?	The more that households have to rely on migrating for income, the higher their vulnerability, as migrants typically lack local work opportunities and earn less income.
	Ratio of non-agricultural income to total income	The ratio of non-agricultural income to total household income of the household	What is your total income? How much of that income comes from agriculture?	A ratio that is heavy on the side of agricultural income is associated with increased vulnerability, agriculture being more susceptible

				to climate change and extreme events/conditions.
Health	Average time required to reach a health facility	Total time (minutes) it takes to travel to the nearest health facility (local clinic, hospital, and MBBS doctor)	How much time does it take you to get to the nearest health facility?	Having to travel long distances to address health needs increases vulnerability.
	Percentage of households experiencing the recent death of infant	Percentage of households who have reported the death of an infant in the last 5 years	Has your household experienced the death of an infant in the last 5 years?	Higher infant mortality is associated with increased vulnerability.
	Percentage of households experiencing the recent death of a family member	Percentage of households who have reported the death of any family member in the last 5 years	Has there been any death in your household in the last 5 years?	The recent death of a household member is associated with increased vulnerability.
	Percentage of households with disease(s) due to climate factors	Percentage of households who have reported contracting any disease(s) due to climate variability/event(s)	Did anyone in your family experience any disease in the last 5 years due to a change in temperature and rainfall or an extreme event?	Disease increases vulnerability.
	Percentage of households reporting stress due to climate factors	Percentage of households who have reported experiencing stress due to temperature/rainfall/extreme event	Did you/your household face any stress due to the changes in temperature and rainfall?	Stress increases vulnerability.
	Percentage of households with disabled members	Percentage of households in which at least one member is reported to be disabled	Are there any disabled people in your household?	Disability increases vulnerability.
Social Networks	Percentage of households receiving assistance from a social network (friends or relatives)	Percentage of households who have received assistance from a social network (friends or relatives) in the last few months	Did your friends or relatives help you in the last few months?	Higher dependency on assistance is associated with increased vulnerability.
	Percentage of households receiving assistance from government and/or NGOs	Percentage of households who have received assistance from the government and/or NGOs in the last few months	Did you receive any assistance from the government or any NGOs in the last few months or during an extreme climate event?	Higher dependency on assistance is associated with increased vulnerability.

	Percentage of households providing help to others	Percentage of households who provided help to others (friends or relatives) during a recent climate event	Did you help someone during the most recent extreme climate event?	Ability to provide assistance indicates reduced vulnerability.
	Percentage of households borrowing money from others	Percentage of households borrowing money from others (friends, relatives, or NGOs) in the last few months	Did you borrow any money from your friends, relatives, or any NGOs in the last few months?	Borrowing money increases vulnerability.
	Percentage of households lending money to others	Percentage of households lending money to others in the last few months	Did you lend money to someone in the last few months?	Ability to lend money indicates reduced vulnerability.
Food	Average number of months during which households struggle to find food (0–12)	The average number of months households struggle to secure enough food (0–12) for their family	Does your household have adequate food the whole year, or are there times that your household does not have enough food? How many months a year does your household have trouble getting enough food?	A higher number of months with insufficient food increases vulnerability.
	Percentage of households not practising homestead gardening	Percentage of households not practising homestead gardening	Do you do homestead gardening?	The practice of homestead gardening is associated with increased vulnerability.
	Percentage of households depending on agriculture for income to buy food	Percentage of households dependent on agriculture to buy food	Does agriculture provide the primary source of income to buy food for your family?	Dependency on farming is associated with increased vulnerability.
	Percentage of households with insufficient food from farming	Percentage of households with insufficient food from farming	Do you get enough food for the year from your farm?	The higher the number of households who do not get enough food from farming, the higher the vulnerability.
	Percentage of households experiencing decreased food production	Percentage of households producing less food for themselves or for market	Is the amount of food produced on your land decreasing?	Decreases in food production are associated with increased vulnerability.
	Percentage of households having lost agricultural land	Percentage of households who reported a loss of agricultural land due to extreme climate events	Did you lose any land due to (an) extreme climate event(s)?	Loss of agricultural land is associated with increased vulnerability.
Water	Percentage of households with	Percentage of households do not have access to potable water throughout the year	Is potable water available for your household throughout the year?	A lack of access to potable water increases vulnerability.

	difficulties accessing portable water			
	Percentage of households dependent solely on rainwater harvesting for drinking	Percentage of households who are dependent solely on rainwater harvesting for drinking	Do you collect rainwater for drinking throughout the year?	A higher reliance on rainwater harvesting increases vulnerability.
	Percentage of households using unsafe drinking water	Percentage of households who use unsafe drinking water (from a river, pond, hole, or canal, or arsenic-contaminated water)	Where do you get your drinking water? Is/Are these source(s) safe?	Drinking unsafe water increases vulnerability.
	Average time required to access a safe drinking water source	Average time (minutes) it takes to travel to a safe drinking water source	How long does it take you (minutes) to reach a safe source of drinking water?	The higher the distance travelled to access safe drinking water, the higher the vulnerability.
	Percentage of households reporting water conflicts	Percentage of households who have seen or experienced water conflicts	In the past year, did you experience or see any conflicts over water in your community?	Water conflicts increase vulnerability.
Natural Disasters	Average number of disasters that have occurred in the past 5 years (2015–2019)	Total number of floods/cyclones reported by the household	How many floods/cyclones have you experienced in the last 5 years?	The higher the number of disasters experienced, the higher the vulnerability.
	Percentage of households with an injury or death as a result of extreme climate events in the last 5 years	Percentage of households who reported either injury or death of family member(s) as a result of (an) extreme climate event(s) in the last 5 years	Was anyone in your household injured in this/these extreme climate event(s)? Did anyone in your household die in this/these extreme climate event(s)?	The injury or death of a household member increases vulnerability.
	Percentage of households with injury or death of livestock due to extreme climate events in the last 5 years	Percentage of households who reported either injury or death of livestock due to (an) extreme climate event(s) in the last 5 years	Was there any death or injury of livestock in this/these extreme climate event(s)?	The injury or death of livestock increases vulnerability.
	Percentage of households losing housing or property due to a recent extreme climate event	Percentage of households who reported the loss of housing or property (full or partial) due to a recent extreme climate event	Did you experience the full or partial loss of your house or property during a recent extreme climate event?	Damage and loss to home and/or property increases vulnerability.

	Percentage of households that did not receive warning before the last extreme climate event	Percentage of households that did not receive a warning before the last extreme climate event	Did you receive a warning before the last extreme climate event happened?	Ability to receive flood/cyclone warnings reduces vulnerability.
Climate Variability	Perception index of summer temperature (higher than average)	Percentage of households who reported observing higher than average summer temperatures	Have you observed any change in summer temperature?	Increasing summer temperature increases vulnerability.
	Perception index of winter temperature (lower than average)	Percentage of households who reported observing lower than average winter temperatures	Have you observed any change in winter temperature?	Increasing winter temperature increases vulnerability.
	Perception index of total rainfall (no change)	Percentage of households who reported observing a change in total rainfall	Have you observed any change in total rainfall?	A change in total rainfall increases vulnerability.
	Perception index of monsoon rainfall (no change)	Percentage of households who reported observing a change in monsoon rainfall	Have you observed any change in monsoon rainfall?	A change in monsoon rainfall increases vulnerability.
	Perception index of rainfall in winter months (no change)	Percentage of households who reported observing a change in winter rainfall	Have you observed any change in the winter month's rainfall?	A change in winter rainfall increases vulnerability.
	Perception index of frequency of extreme climate events (more frequent)	Percentage of households who reported observing more frequent extreme climate events	Do you think that extreme climate events happen more frequently?	The frequent occurrence of extreme climate events increases vulnerability.
	Perception index of severity of extreme climate events (more severe)	Percentage of households who reported an increase in the severity of extreme climate events	Do you think that recent extreme climate events are more severe than those you experienced in the past?	The occurrence of severe extreme climate events increases vulnerability.

Source: Adapted from Pandey and Jha (2012).

5.4.1 Influences of major components and sub–components on the dimensions of CVI: adaptive capacity, sensitivity, and exposure

Using the coded data from the household surveys and the equations described in Section 5.4, the actual, maximum, minimum, and standardised values of the CVI sub-components were calculated. These values, the resulting values of indexed dimensions, and the overall CVI value for flood- and cyclone-affected regions are shown in Table 5.3. At the end of this chapter, a spider diagram (Figure 5.7) and a triangle diagram (Figure 5.8) illustrate the CVI and compare the results from the two villages. The following section presents the results of the CVI assessment according to their vulnerability dimensions: adaptive capacity, sensitivity, and exposure. The higher value of sub-components and primary components indicates the higher vulnerability of a community.

The *adaptive capacity* of flood- and cyclone-affected households, is assessed with the following primary components: socio–demographic state, livelihood, and social networks (Table 5.3). In this study, the primary component of *socio-demographic profile* was measured using four indicators. Significant differences were observed between the socio-demographic profiles of the survey participants in the two study sites. The family dependency index was higher in the flood-hit village (.370) than in the cyclone-hit village (.220). The proportion of families in which the head of household did not attend school was also higher for the flood-hit village (.490) than the cyclone-hit village (.370), the flood-hit village had a higher family size (.360) than the cyclone-hit village (.160), and the flood-hit village had a lower diversity of house types (.050) than the cyclone-hit village (.130). Households living in the flood-hit village reported that their kutcha houses with mud and coconut leaf walls are susceptible to heavy rainfall and flooding, as they collapse easily. Because the floodwater enters the settlement area, households would prefer to use tin for roofs and walls: these would not collapse as easily as a kutcha house. However, many household survey respondents from Lamagaon could not afford such houses. Overall, the socio-demographic profile suggests that the flood-hit village is more vulnerable than the cyclone-hit village to the adverse effects of extreme climate events.

The results associated with *livelihood strategies* also varied across the two study areas. While the average agricultural livelihood diversification index was similar in both villages, the number of households depending on agriculture as their primary income source was higher in the flood-hit village (.918) than in the cyclone-hit village (.735). In contrast, the percentage of households with members who migrated for work and that were dependent on agricultural income was higher among the respondents in the cyclone-hit village than among those in the flood-hit village. The occupational calendar (discussed in Chapter Four) showed that many male members of the cyclone-affected village migrate seasonally—in the dry seasons (November to April)—for four to six months. According to the overall index value for this component, the livelihood strategies of cyclone-prone households (.556) were more likely to be vulnerable to extreme climate events than those of flood-prone households (.483) (Table 5.3).

The third major component of adaptive capacity is the household's *social network*. The overall index for social networks was .299 for survey respondents in the flood-hit village and .378 for those in the cyclone-hit village. This suggests that, with respect to their social networks, cyclone-affected households were more vulnerable than flood-affected households. Households in the flood-hit village that participated in the survey relied to some extent on assistance provided by friends, relatives, and governmental and non–governmental organisations. The percentage of households receiving assistance from these sources was more than double in the cyclone-hit village compared to the flood-hit village. Participants in the flood-hit village were better able to help those around them in need: 12.5 percent of households in the cyclone-hit village and 25.1 percent in the flood-hit village reported that they assisted their friends and relatives, and more households in the flood-hit village (.251) than in the cyclone-hit village (.163) were able to lend money to others. The percentage of households with who borrowed from others was similar (Table 5.3).

Table 5.3 Climate vulnerability index: estimated overall, maximum and minimum scores for primary components in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Primary component	Sub-components	Sub-component values [a higher value indicates a higher vulnerability]		The maximum value of each sub-component for all districts	The minimum value of each sub-component for all districts	Primary component values [a higher value indicates a higher vulnerability]	
		Cyclones	*Floods*			*Cyclones*	*Floods*
Socio–demographic profile	• Family dependency index	0.220	0.370	3	0		
	• Percentage of households (HHs) in which the head has not attended school	0.370	0.490	100	0		
	• The average number of family members in the HHs	0.160	0.360	11	3		
	• Percentage of HHs with *kutcha* houses	0.130	0.050	100	0	0.220	0.318
Livelihood strategies	• Average agricultural livelihood diversification index	0.453	0.414	1	0.17		
	• Percentage of HHs dependent solely on agriculture as a source of income	0.735	0.918	100	0		
	• Percentage of HHs with members who migrate for work	0.447	0.139	100	0		
	• The ratio of agricultural income to total income	0.590	0.459	1	0.33	0.556	0.483
Health	• Average time (minutes) to a health facility	0.217	0.537	60	1		
	• Percentage of HHs with the recent death of infant	0.176	0.130	100	0		
	• Percentage of HHs with the recent death of (a) household member(s)	0.227	0.091	100	0		
	• Percentage of HHs with disease due to climate factors	0.211	0.260	100	0		
	• Percentage of HHs with stress due to climate factors	0.265	0.121	100	0		

	• Percentage of HHs with disabled members	0.045	0.035	100	0	0.190	0.196
Social Network	• Percentage of HHs that received assistance from a social network (friends or relatives)	0.649	0.303	100	0		
	• Percentage of HHs that received assistance from the government and/or NGOs	0.636	0.294	100	0		
	• Percentage of HHs that provided help to others	0.125	0.251	100	0		
	• Percentage of HHs that borrowed money from others	0.319	0.398	100	0		
	• Percentage of HHs that lent money to others	0.163	0.251	100	0	0.378	0.299
Food	• The average number of months HHs struggle to find food (0–12)	0.317	0.360	12	0		
	• Percentage of HHs that did not practising homestead gardening	0.572	0.654	100	0		
	• Percentage of HHs that depended on agriculture for income to buy food	0.252	0.364	100	0		
	• Percentage of HHs with insufficient food from farms	0.869	0.840	100	0		
	• Percentage of HHs with decreasing food production	0.291	0.208	100	0		
	• Percentage of HHs that lost agricultural land	0.150	0.065	100	0	0.409	0.415
Water	• Percentage of HHs with a problem with access to portable water	0.518	0.108	100	0		
	• Percentage of HHs dependent solely on rainwater harvesting for drinking	0.812	0.009	100	0		
	• Percentage of HHs that use unsafe drinking water	0.805	0.013	100	0		
	• Average time (minutes) to travel to a safe drinking water source	0.261	0.128	60	0		

	• Percentage of HHs that reported water conflicts	0.326	0.043	100	0	0.544	0.060
Natural Disasters	• The average number of disasters in the past 5 years	0.900	0.780	2	1		
	• Percentage of HHs with an injury or death as a result of (an) extreme climate event(s) in the last 5 years	0.188	0.126	100	0		
	• Percentage of HHs with an injury or death of livestock due to (an) extreme climate event(s) in the last 5 years	0.514	0.351	100	0		
	• Percentage of HHs that lost housing or property due to a recent extreme climate event in the last 5 years	0.514	0.745	100	0		
	• Percentage of HHs that did not receive a warning before the last extreme climate event	0.038	1.000	100	0	0.431	0.600
Climate Variability	• Perception index of summer temperature	0.783	0.701	100	0		
	• Perception index of winter temperature	0.588	0.636	100	0		
	• Perception index of total rainfall	0.696	0.537	100	0		
	• Perception index of monsoon rainfall	0.690	0.563	100	0		
	• Perception index of winter rainfall	0.639	0.320	100	0		
	• Perception index of frequency of extreme climate events	0.681	0.970	100	0		
	• Perception index of severity of extreme climate events	0.709	0.506	100	0	0.684	0.605

Data source: Household Survey, 2019–2020.

The *sensitivity* component of household vulnerability, is assessed with the following primary components: health, food, and water. According to the data, the reported *health* conditions were somewhat similar in both study areas, however, there were differences within the contributing factors. For example, the approximate time it took to reach the nearest health facility of each village differed significantly: the mean time for a person in the cyclone-hit village to do so was 14 minutes, whereas it took 26 minutes in the flood-hit village. The percentages of households that had experienced the deaths of an infant and, recently, a household member were 17.6 percent and 13 percent in the cyclone-hit village and 22.7 percent and 9.1 percent in the flood-hit village, respectively. Some households in both study areas reported that changes observed in the climate had caused critical health problems, primarily related to heatwaves and extreme cold temperatures. Escalated stress levels associated with climate change were reported in the cyclone-hit village hit, most likely because the people in this village are completely reliant on natural resources for livelihood and cyclones increase soil and groundwater salinity. Households in both regions households reported a low incidence of disability (Table 5.3).

Another critical component of sensitivity is *food*, which arguably contributes most significantly to household vulnerability. The number of months during which a household struggles to get food was higher in the flood-hit village (.360) than in the cyclone-hit village (.317). Most of the households in both areas reported not practising homestead gardening. It was found that the salinity in the soil and groundwater in the cyclone-hit village and the regular flooding in the flood-hit village made it difficult to rely on homestead gardening. The proportion of households depending on agriculture to grow staple food and generate income to buy other essential products was higher in the flood-hit village (.364) than in the cyclone-hit village (.252). That said, most households in both areas reported that farming did not produce sufficient food and income (.840 and .869 in the flood-hit and the cyclone-hit villages, respectively), and that they had experienced a decrease in food production (.208 and .291 in the flood-hit and the cyclone-hit villages). Finally, 15 percent of the households surveyed in the cyclone-hit village and 6.5 percent in the flood-hit village had lost land due to extreme climate events. Overall, it can be concluded from this part of the assessment that both regions were similarly vulnerable regarding the food component of sensitivity (Table 5.3).

The last component of sensitivity is water, for which participating households living in the cyclone-hit village had a much higher vulnerability score for water components (.544) than did those from the flood-hit village (.060). The percentage of households with a problem with access to portable water was around five times higher for the cyclone-hit village than for the flood-hit village. Households in the cyclone-hit village primarily relied on rainwater harvesting for drinking, as they were generally unable to use or drink their local groundwater due to salinity. These households noted the deficiency of precipitation in dry season, an increase in the salinity of both surface and groundwater, and extreme temperature as factors that hindered their access to safe drinking water sources. Villagers affected by Cyclone Aila in 2009 witnessed a tremendous shortage of drinking water. The water supply system in many regions of the Shyamnagar sub-district of Satkhira district has deteriorated since Cyclone Aila damaged many protected ponds, pond sand filters, and tube wells. Many have had to drink contaminated water as there was no alternative. In this study, 80.5 percent of participating households in the cyclone-hit village reported using an unsafe source of drinking water for drinking and cooking, while this was the case for only 13 percent households in the flood-hit village. To access safe drinking water, they needed to travel 26 minutes in the cyclone-hit village and 8 minutes in the flood-hit village. One-third of households in the cyclone-hit village reported water-related conflicts over ownership and use of water sources, while this was the case for only 4.3 percent of households in the flood-hit village (Table 5.3).

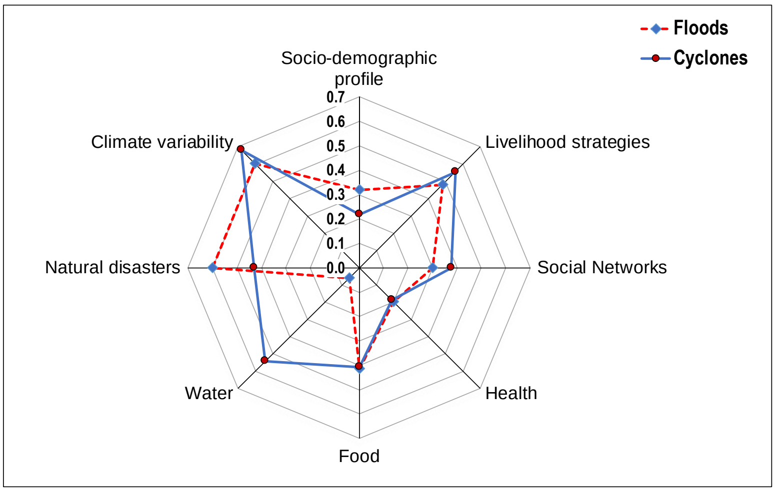
The primary components of natural disasters and climate variability are used to evaluate the *exposure* component of household vulnerability. With regard to *natural disasters*, it was found that the frequency of extreme climate events was higher in the cyclone-hit village (.900) than in the flood-hit village (780); households in the cyclone-hit village were more likely to be exposed to multi-hazards associated with tropical cyclones, such as salinity, tidal surges, and floods. According to Ahmed and Tan (2021), coastal areas in Bangladesh are incredibly vulnerable to such multi-hazards. Participating households from this cyclone-hit village were also more affected than those from the flood-hit village by the injury or death of household members (.188 and .126, respectively) or livestock (.514 and .351, respectively) due to the adverse effects climate events. The apparent lower incidence of such losses in the flood-hit village could be due to the slow onset of flood effects and the apparent lower sensitivity of this village in health, food, and water components. However, the loss of housing or property due to a recent extreme climate event was higher in the flood-hit village (.745) than was the case in the cyclone-hit village (.514). Most of this loss of and damage to standing crops in Lamagaon was caused by a rapid onset flood in 2017. Respondents in this flood-hit village reported that they had lost all their standing crops due to this flash flood. In contrast, less loss and damage to houses and properties was associated with the last two cyclones experienced by the residents of Chadnimukha in 2019.

The existence and efficient operation of an emergency warning system can make communities less vulnerable to extreme climate events. Bangladesh has made progress in building pre–cyclone warning systems (Roy et al., 2015; Syed et al., 2021), which have become the primary sources of information that enable people to develop a strategy for mitigating the effects of cyclones on their lives and livelihoods. The Bangladesh Meteorological Department (BMD) has a specialised unit, the Storm Warning Center (SWC), which is designed to forecast and issue tropical cyclone warnings in Bangladesh. This cyclone early warning system has significantly decreased cyclone-related fatalities (Syed et al., 2021) and can be used to explain the extremely low result for this factor in the cyclone-hit village (.038). However, all flood-affected participants stated that that they seldom receive any flood forecast warning (.100). Flash floods come overnight, so they believed that a flash floods would reach them before they could receive a flood warning. According to Syed et al. (2021), while the system for disseminating early cyclone warnings up to the sub-district level of Bangladesh is operational and largely effective, the dissemination system for flood warnings s is not fully developed. Considering all the data presented above, it can be argued that flood-hit villages are more vulnerable to extreme climate events than are cyclone-hit villages (Table 5.3).

The data reveals a slight difference between the two regions in the estimated index value associated with *climate variability*, the other component that reflects the exposure dimension of vulnerability. Overall, climate variability was slightly higher in the cyclone-hit village (.684) than in the flood-hit village (.605). However, noticeable differences were found among the sub–components. The perception index of summer and winter temperature showed a few variations. Most households noticed an increase in summer and winter temperature, which is consistent with the region's meteorological records (Hasan & Kumar, 2019, 2020; Hasan & Nursey-Bray, 2018; Shameem et al., 2015). A considerable variation was revealed for the rainfall perception index. Rainfall perception index, such as changes in total annual rainfall, monsoon, and winter, was higher in the cyclone–hit village than the flood–hit village. In both regions, most households reported significant declines in total rainfall and monsoon rainfall. However, their perception of rainfall in the winter months differed: most households in the cyclone-hit village reported a decrease, while in the flood-hit village, most households reported either a decrease or a fluctuation. All perceptions (except for those reported by participants from the flood-hit village of rainfall in the winter months, as discussed in Chapter 4) align with the meteorological data. Respondents in the flood-hit area reported having experienced a higher frequency of extreme climate events (.970) than those in the cyclone-hit village (.681). The respondents from Lamagaon reported that they experienced a couple of flash floods in each flood season, each year, between May and September. Unlike floods, cyclones, although they have a season (between April–May and October–November), do not occur every year. Regarding the perception index of the severity of extreme climate events, the cyclone-affected village is seen to be more vulnerable (.709) than the flood-affected village (.506) (Table 5.3).

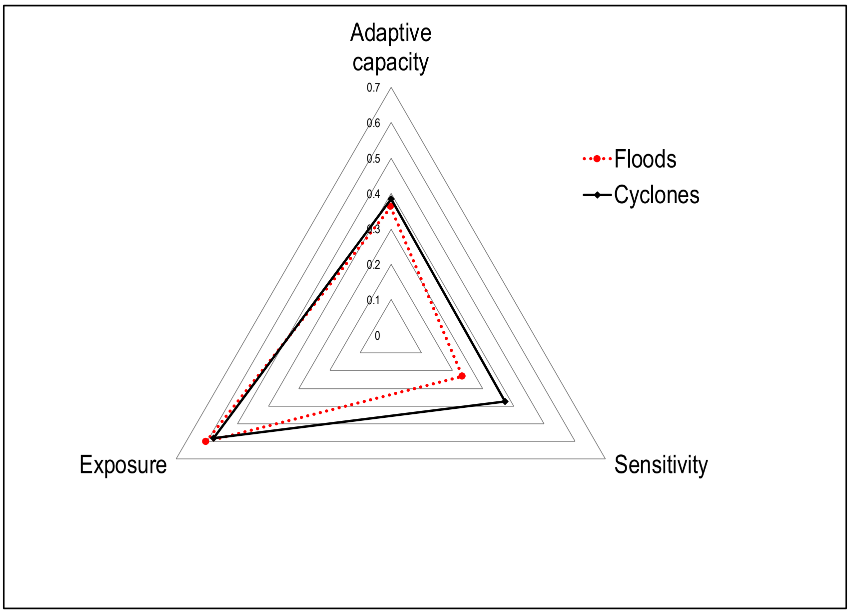
The CVI scores for the primary components are presented in a spider diagram (Figure 5.7) and the vulnerability dimensions are illustrated using a triangle diagram (Figure 5.8). The scale for the spider diagram ranges between 0 (less vulnerable) at the centre to 0.7 (more vulnerable) at the outside edge, with increase steps of 0.1 unit. The spider diagram shows that the cyclone-affected village is more vulnerable in terms of livelihood, social networks, water, and climate variability. In contrast, the flood-affected village was more vulnerable in terms of its socio-demographic profile and its exposure to natural disasters. It also reveals that the health and food status of both villages were similar, despite the different physical settings of and vulnerability to different hazards of these households as shown earlier in Figure 5.1.

Figure 5.7 Spider diagram comparing scores for the primary components of the climate vulnerability index (CVI) calculated for the villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).



Data source: Household Survey, 2019–2020.

Figure 5.8 Vulnerability triangle diagram comparing scores for the three dimensions of vulnerability calculated for the villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*), based on index values used to calculate CVI.



Data source: Household Survey, 2019–2020.

The triangle diagram in Figure 5.8, which plots the scores for the three dimensions contributing to vulnerability—adaptive capacity, sensitivity, and exposure—ranging between 0 (low contribution to vulnerability) and 0.7 (high contribution), is presented to offer greater clarity. The diagram shows that, while the exposure and adaptive capacity of both flood-hit and cyclone-hit villages were quite similar, the cyclone-hit village revealed significantly greater sensitivity to climate events.

The weighted scores of the three dimensions and the overall CVI are presented in Table 5.4. The index value of the three dimensions contributed the calculation of the CVI of the households. The high value of the CVI in both areas (.897 for the flood-hit village and .998 for the cyclone-hit village) indicates that both are considerably vulnerable to climate change. Ultimately, according to this assessment, cyclone-affected households were found to be slightly more vulnerable than flood-affected households.

Table 5.4 Indexed dimensions of the vulnerability in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Vulnerability dimension	**Primary components**	**Index value of the vulnerability dimension [higher value indicates higher vulnerability]**	
		Cyclones	***Floods***
Adaptive capacity	Socio-demographic profile Livelihood strategies Social Networks	.385	.362
Sensitivity	Health Food Water	.372	.234
Exposure	Natural disasters Climate variability	.579	.603
Climate vulnerability index (CVI)		.998	.897

Data source: Household Survey, 2019–2020.

5.5 Conclusion

This chapter detailed the process used to determine which of the study areas were most susceptible to variations in climate and to extreme climate events: identify climate trends, identify villagers' perceptions of these trends, relate data collected from the household surveys to the Climate Variability Index (CVI) framework, use indexing techniques to turn the immeasurable data from the household surveys into measurable data, and use and report the derived values within the CVI, and, finally relate these to the three dimensions of vulnerability.

It was found that the climate change perception of the women surveyed is consistent with both meteorological observations and the perceptions of their male counterparts. This confirms that women's understanding of climate change variability and extreme events can and should be incorporated into the development of disaster risk reduction programs to facilitate coping and adaptation strategies of individuals and households that can improve their health and well–being. This finding can support the design and implementation of climate change adaptation and mitigation strategies that local inhabitants will accept.

It was also found that Chadnimukha, a village hit by cyclones, was more vulnerable to climate change and associated extreme climate events than Lamagaon, a village hit by floods. Overall findings suggest that the cyclone-affected village in this study is more vulnerable with respect to livelihood strategies, social networks, water, and climate variability. In contrast, the flood-affected village in this study is more vulnerable in terms of socio–demographic dimensions and natural disaster exposure. However, the health and food components were similar in both the villages, despite their different physical settings and their vulnerability to different hazards. Regarding the dimensions of vulnerability, the exposure and adaptive capacity are similar for both communities, and the sensitivity is higher for the cyclone-affected community than for the flood-affected one. These findings provide evidence that could help policymakers develop measures for disaster prevention, mitigation, and preparedness that are better tailored to the contexts and needs of such communities.

The findings of this chapter indicate that different hazards can have differential effects on households, including but not limited to their effects on fertility. The previous chapter revealed that women had fewer children and were less likely to intend to have additional children in the cyclone-prone village; this could be associated with their particular vulnerabilities with respect to livelihoods, social networks, and water, all of which can affect the processes of fertility. The next chapter uses the insights gained from the research and the analysis of the data described up to this point to further investigate the ways in which extreme climate events influence fertility.

Chapter 6 Fertility and the Effects of Extreme Climate Events

6.1 Introduction

According to the IPCC Sixth Assessment Report, climate change is driving the increased frequency and intensity of extreme climate events. Incremental increases in global temperatures as small as +0.5°C have been found to cause statistically significant changes to the quantity and severity of extreme events, especially those associated with temperature and precipitation, including but not limited to tropical cyclones and droughts (Seneviratne et al., 2021). According to numerous studies, the adverse effects of extreme climate events are influencing significant changes to the population dynamics—mortality, migration, and fertility—of many countries (Casey et al., 2019; Frankenberg et al., 2015; Frey & Singer, 2010; Jiang & Hardee, 2011; Muttarak, 2021). However, the impact of extreme climate events on fertility dynamics has, to date, not received much scholarly attention. Exploring how extreme climate events affect fertility, and linking climate with human fertility and reproductive health research at the individual and community levels, can provide insights into the proximate determinants of fertility dynamics under climatic change or extreme climate events and contribute to the development of policy in the face of spatial and temporal variability (Grace, 2017).

This chapter presents an analysis of the data collected from key-informant interviews, focus group discussions, household survey questionnaires, and in-depth interviews to reveal the ways in which extreme climate events shape the fertility of women in Bangladesh. It provides answers to the four underlying research questions introduced in Section 1.3:

1. How do women's experiences and perceptions of extreme climate events influence their fertility?
2. How does household vulnerability to extreme climate events influence women's fertility?
3. Are determinants associated with extreme climate events better able to explain the fertility of women above and beyond established determinants of fertility?
4. How does access to infrastructure, transport, health and reproductive care, and contraception services influence the fertility of women at the time of extreme climate events?

This chapter triangulates both quantitative and qualitative information to explore these research questions and identify the differences between the two study villages, one hit by cyclones (Chadnimukha) and one hit by floods (Lamagaon). It begins by delineating the experiences and perceptions of women about extreme climate events (e.g., cyclones and floods) and how they relate to their fertility. The following section describes to the extent to which the vulnerability of households to extreme climate events influences the fertility of women. The third section examines the effects of socio-demographic and extreme climate event determinants on their fertility. Finally, the aforementioned triangulation of quantitative (e.g., household survey) and qualitative (e.g., key-informant interviews with stakeholders, focus group discussions with male participants, and in-depth interviews with married women) findings helps to reveal the ways in which climate-induced extreme events affect the fertility of women in different ways in cyclone- and flood-affected areas. These findings help to identify determinants that are likely to influence the fertility intentions of women, which are discussed in greater detail in Chapter 7.

6.2 Fertility of women in the study areas

The key dependent variable used in this study is the number of *children ever born*, which is a measure of the number of children among married women aged 15 years or more, and it includes all live births living or dead up to the time of data collection. Children ever born is also referred to as a summary of birth histories which quantify all the live births a woman has experienced in her lifetime. Data on children ever born for successive age groups of women provide information about trends in childbearing, which can be used to predict fertility behaviour of a given region if census and survey data are inadequate or missing.

Findings from this study, as shown in Table 6.1, indicate that the mean number of children ever born as well as the number of those who survived was significantly higher in the flood-hit village than in the cyclone-hit village. The mean number of children ever born to household survey respondents was 3.75 in the flood-hit village and 2.06 in the cyclone-hit village. It was found that women of different age groups in the flood-hit village had more children than those living in the cyclone–hit village. Notably, younger respondents aged 18 to 24 years in the cyclone-hit village had lower numbers of children ever born (mean = 1.32) than their counterparts in the flood-hit village (mean = 1.79).

Table 6.1 Fertility of women respondents in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Age of respondent	*Cyclones*	*Floods*
Number of children ever born (Mean/SD)		
18–24	1.32 (.52)	1.79 (.84)
25–34	2.10 (.88)	3.53 (1.40)
35–49	2.55 (.99)	5.20 (1.79)
Total	**2.06 (.96)**	**3.75 (1.88)**
Number of children alive (Mean/SD)		
18–24	1.21 (.40)	1.62 (.69)
25–34	1.90 (.74)	3.05 (1.13)
35–49	2.34 (.84)	4.39 (1.47)
Total	**1.88 (.82)**	**3.22 (1.52)**

Source: Household Survey, 2019–2020.

Differences in fertility between the areas hit by cyclones and floods are likely to be associated with socio-demographic, economic, social, and extreme climate event determinants.

6.3 Women's experiences and perceptions of extreme climate events

Disaster risk reduction approaches have established that adaptive behaviours are influenced by an individual's perception of climate change variability or extreme climate events as well as their disaster experience (Dillon et al., 2011; Silver & Andrey, 2014). Researchers on climate change adaptation argue that the experience of a hazard can lead individuals to learn about and update their prior expectations of risk and influence their subsequent behaviour (Adger et al., 2013; Palmer & Smith, 2014). It is important to understand the experience and perceptions of individuals within the context of the extreme climate events to which they are exposed, as the subjective of their encounters with such events influences their decisions (Dzialek, 2013). This research examines the experiences and perceptions of women from the two study areas about the extreme climate events they face through selected statements that were developed from a review of the literature.

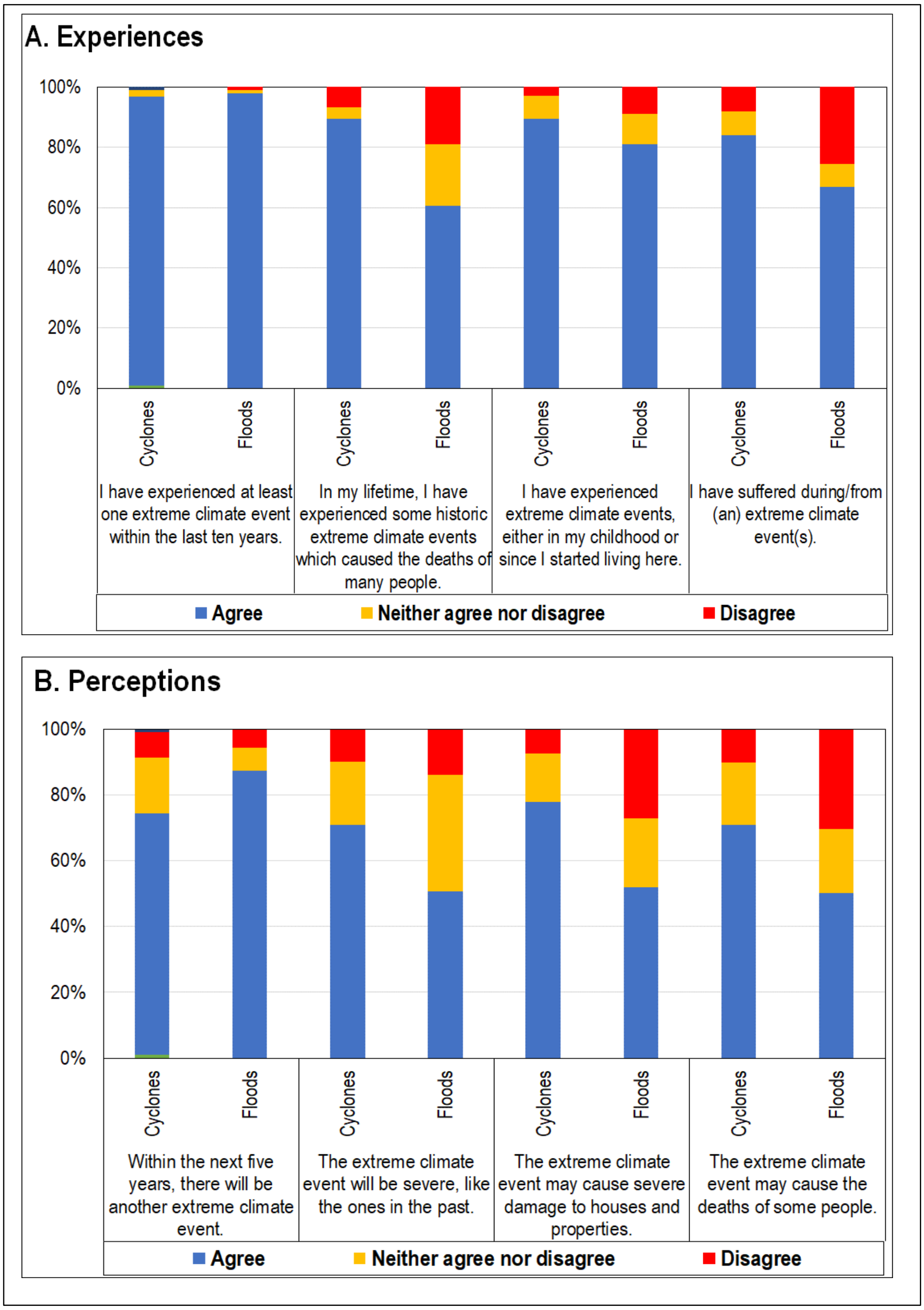
These statements and the participating women's responses to the statements are presented in Figures 6.1 A and B. The statements were initially scored through a five-point Likert scale in which 1 meant "strongly disagree" and 5 meant "strongly agree". The collected data include eight statements, and factor analysis was employed to explore the patterns of the responses on statements. Before the factor analysis, the reliability of the scale items was checked through Cronbach's Alpha, which generated coefficients of .899 for the cyclone-hit village and .869

for the flood-hit village, suggesting that the scale items have relatively high internal consistency (see *Table C8, Appendix C*). In addition to computing the alpha coefficient of reliability, the dimensionality of the scale was investigated by factor analysis (using Principal Component Analysis for extraction, and Varimax with Kaiser Normalization for rotation). Factor analysis takes a mass of data and reduces it to a smaller, more consistent data set. It is a method of finding hidden patterns and reducing overlap (Choon et al., 2019). This factor analysis reduced all statements into two factors of *experience* and *perceptions*, and accounts for 79.5 percent and 83.8 percent total variations identified in cyclone-hit and flood-hit villages, respectively. This suggests that the scale items are unidimensional.

Figure 6.1 A shows the responses to statements related to the household survey respondents' experience of extreme climate events and Figure 6.1 B shows their perceptions. Their responses were reduced from five to three primary groups for better presentation in graphs: "agree", "neither agree nor disagree", and "disagree". Overall, the findings suggest that women in the cyclone-hit village had comparatively more experience of extreme climate events (e.g., cyclones) and were more in agreement with statements associated with statements about future frequency and severity of such events. Though a majority of women in both areas agreed with the eight statements, the comparatively higher percentage in the cyclone-hit village can be associated with the destructiveness, frequency, and intensity of the cyclones they have encountered. As shown in Figure 6.1 A, respondents in the cyclone-hit village had experienced a greater number of historic cyclones that caused the deaths of many people (89.5%) and caused them, personally, to suffer (84%) than those from the flood-hit village (60.6% and 66.7%, respectively).

Experience of cyclones or floods typically influences perceptions of future climatic events. Figure 6.1 B shows the perceptions of women regarding the future frequency, severity, and impact of cyclones or floods. Women in the flood-hit village (87.5%) were more likely to perceive that there would be another flood in the next five years (2020–2024) than their counterparts, 75 percent of whom perceived the same of cyclones. It is important to note that women in the cyclone-hit village were more likely to perceive that the future cyclones would be severe (70.9%), would damage houses and properties (77.2%), and involve the loss of human lives (71%). Around 50 percent of their counterparts from the flood-hit village shared these impressions.

Figure 6.1 Responses to statements about women's experience and perceptions of extreme climate events in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).



Source: Household Survey, 2019–2020.

6.4 Effects of the experience of extreme climate events on respondents' perceptions of subsequent events

For this study, it was assumed that respondents' perception scores of extreme climate events were likely to have been influenced by their overall experience scores of such extreme climate events and their effects. To identify and analyse this, a linear regression model was used to understand the influence of their mean scores of experience on their mean scores of perception: this is presented in Table 6.2. Both theoretically and methodologically, it would be helpful to control socio-demographic variables while exploring the influence of experience on perceptions. However, this examination goes beyond the scope of this research, and the current analysis is just to confirm that perception follows experience.

Table 6.2 Effects of experience on perceptions, in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

	Coefficients (p-value)	
Model	***Cyclones***	***Floods***
Mean score of perceptions	**.703**	**.334**
R^2	.237	.085
Adjusted R^2 =	.234	.081
F (p)	96.392 (.000)	21.380 (.000)

Source: Household Survey, 2019–2020.

The linear regression model shows that the coefficients of mean score of perceptions significantly increased by .703 and .334 in the cyclone-hit village and the flood-hit village, respectively, with an increase in the mean score of experience. Moreover, the adjusted R^2 value, 23.4 percent for the cyclone-hit village and 8.1 percent for the flood-hit village, indicates that the change in the mean score of perceptions by 1 unit with a change in the mean score of experience was likely to be more significantly associated with the experience of cyclones than floods. This finding is in line with much of the existing literature on climate change perceptions, confirming that the experience of a climatic event often determines how people perceive the climate to be changing (Ayanlade & Jegede, 2016; Haq & Ahmed, 2020).

6.5 Differential effects of the experience of extreme climate events on desired fertility

The total number of children that a woman says, at a given point in time, that she would like to have in her lifetime is referred to as her desired or ideal fertility. One household survey question asked women: "If you could go back to the time when you did not have any children and could choose the exact number of children to have in your whole life, how many would that be?" Their responses to this question were used to identify the indirect effects of experience on desired fertility as examined through the women's perceptions of extreme climate events. The age of respondents at the time of the survey and the number of extreme climate events they had witnessed by women in each village were included in the path analysis, as they are potential confounders that can mediate the perception of extreme climate events. The mean and standard deviation of the variables selected for path analysis are shown in Table 6.3. Women in the flood-hit village desired more children (3.04) than those in the cyclone-hit village (2.18). Though women in the flood-hit village had experienced a greater number of extreme climate events (3.22), they had less frequently witnessed and perceived the adverse effects of floods than those who had experienced the adverse effects of cyclones.

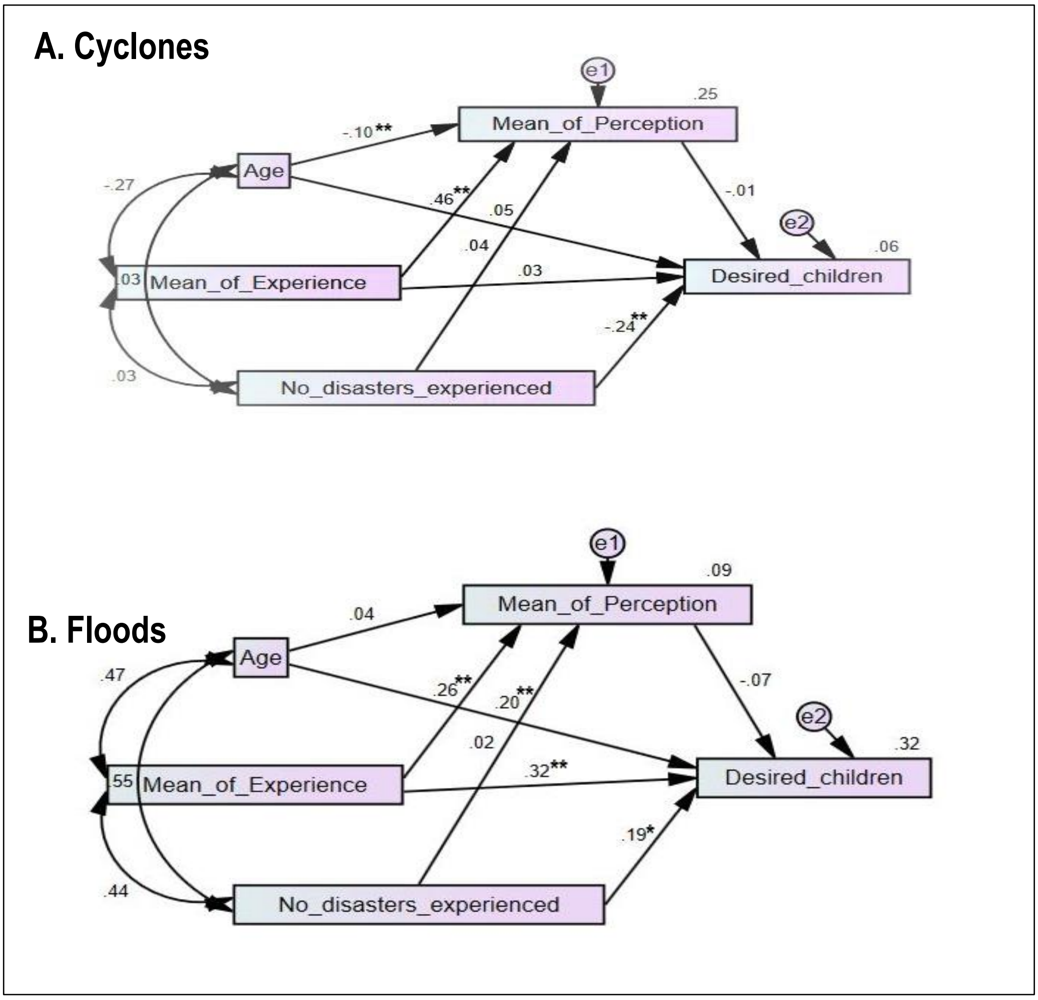
Table 6.3 Mean (SD) of variables used for path analysis of the direct and indirect effects of the experience of extreme climate events on women respondents' desired number of children in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Variables	*Cyclones*	*Floods*
Desired number of children	2.18 (.624)	3.04 (1.06)
Age	30.35 (6.8)	30.66 (7.08)
Number of extreme climate events	2.54 (1.24)	3.22 (1.78)
Score of extreme climate events' experiences	4.29 (.644)	4.08 (.931)
Score of extreme climate events' perceptions	3.98 (.931)	3.73 (1.06)

Source: Household Survey, 2019–2020.

The direct, indirect, and total effects of the mean score of the experience of extreme climate events on fertility (measured by the desired fertility) are examined by path analysis, as shown in Figure 6.2. The standardised path coefficients from the path analysis are shown in Figure 6.2 for villages hit by cyclones (A) and those hit by floods (B). According to the results, age has a significant negative effect on the mean score of perception only in the cyclone-hit village, which indicates that the perceptions of future increases in the frequency and/or severity of extreme climate events decrease with an increase in the age of women in the cyclone–hit village. The path diagrams for A and B reveal that the mean score of experience has a significant and positive impact on the mean scores of perceptions in both villages: an increase in the mean score of experience by one standard deviation of its mean values increased the mean score of perceptions by .46 and .26 standard deviation of its mean values in the cyclone-hit village and the flood-hit village, respectively. The mean score of perceptions had no significant effect on the desired number of children, however, the coefficients of perceptions suggest that perceptions had a negative impact on the desired number of children in both areas: increasing the mean score of perception by one standard deviation of its mean values decreased the number of desired children by .01 and .07 standard deviation of its mean values in the cyclone-hit village and the flood-hit village, respectively.

Figure 6.2 Path diagram showing the direct and indirect effects of the experience of extreme climate events on women respondents' desired number of children in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).



Note: * p<0.05, ** p<0.01.
Source: Household Survey, 2019–2020.

The path analysis indicates that the number of extreme climate events experienced by the household survey respondents had a significant impact on their fertility, and that the impact differed according to the type of extreme event, with cyclones having a negative impact and floods having a positive impact. In other words, given an increase of one standard deviation of the mean value of the number of extreme climate events experienced by women, the fertility of women decreased by .24 in the cyclone-hit village and increased by .19 standard deviation of its mean value in the flood-hit village. The age of women and the mean score of their experience of extreme climate events had significant direct positive effects on the desired number of children in the flood-hit village: the number of desired children increased by .20 and .32 standard deviation of their mean values, increasing the mean score of age and the mean score of experience by one standard deviation of their mean values. The age of women was significantly associated with their experience score (coefficient is .55) and the frequency of floods (coefficient is .44), as indicated by the correlation coefficient in the path diagram (Figure 6.2 B). That is to say, the mean score of experience and the frequency of floods experienced by a woman increased with an increase in her age. As a result, older women in the flood-hit village had higher fertility.

The direct, indirect, and total effects of all selected determinants are shown in Table 6.4. There was no significant direct, indirect, or total effect of age, the mean score of experience, and the mean score of perceptions on desired fertility in the cyclone-hit village. Only the number of cyclones that a respondent had experienced had a significant negative direct and total effect on their desired fertility. This indicates that respondents tended to desire fewer children if they had experienced a greater number of cyclones.

In contrast, in the flood-hit village, the age of respondents, the mean score of experience, and the number of extreme climate events experienced by a woman had significant positive direct and total impacts on the desired number of children. However, there was no significant indirect effect through perceptions of any determinants on desired fertility. In summary, Table 6.4 shows that the desired fertility of respondents in the flood-hit village significantly increased with an increase in their age, the mean score of their experience of extreme climate events, and the number of floods they had experienced in their lifetime.

Table 6.4 Direct, indirect, and total effects of selected determinants on desired fertility of women respondents in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

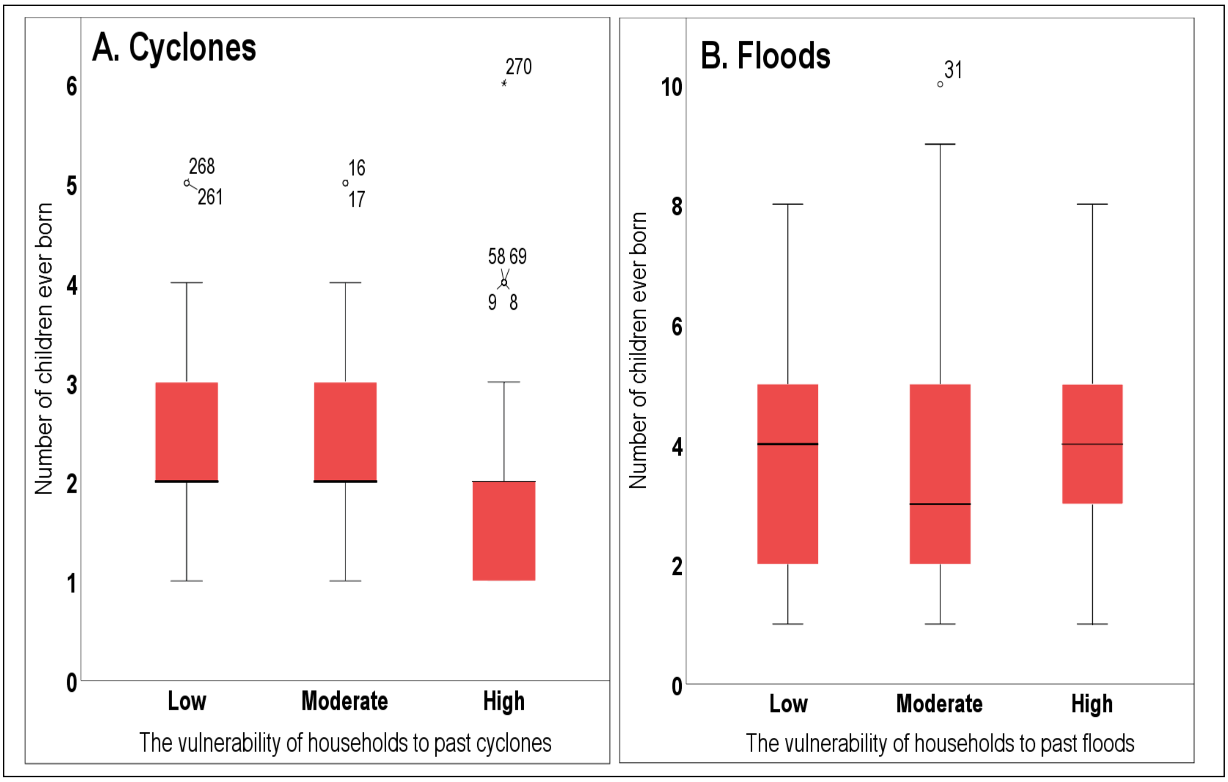
Variables	Direct effect	p–value	Indirect effect	p–value	Total effect	p–value
Cyclones						
Age	.054	.311	.001	.715	.055	.224
Mean of experience	.030	.611	–.005	.822	.025	.689
Mean of perception	–.012	.822	/	/	–.012	.822
Number of extreme climate events	–.237	**.010**	–.001	.571	–.237	**.011**
Floods						
Age	.201	**.003**	–.003	.421	.199	**.003**
Mean of experience	.319	**.005**	–.018	.108	.300	**.004**
Mean of perception	–.069	.185	/	/	–.069	.172
Number of extreme climate events	.195	**.032**	–.002	.465	.193	**.040**

Source: Household Survey, 2019–2020.

6.6 Fertility responses to levels of household vulnerability

As shown earlier in Chapter 4, most of the responding households (57.5%) in Chadnimukha were likely to be "highly" vulnerable to past cyclones. In contrast, in Lamagaon, only 13 percent were "highly" vulnerable; the majority of this group, representing about half the households (49.4%), were "moderately" vulnerable to past floods (refer to *Table 4.8*). Simultaneously, the fertility of respondents was higher in the village hit by floods (see Table 6.1). This indicates that the vulnerability of a household is likely to influence the fertility of women. In order to examine whether there is a statistically significant difference between different groups of vulnerable households (e.g., low, moderate, high) and the mean number of children ever born to a woman, an ANOVA test was employed. No outliers affected the overall analysis, and the data was normally distributed for each group as assessed by box plots (Figure 6.3). Homogeneity of variances was met, as shown in Table 6.5 by Levene's Test of Homogeneity of Variance (p = .140 for the cyclone-hit village and .625 for the flood-hit village). This means that the ANOVA test can be considered to be robust.

Figure 6.3 Box plots for checking outliers of household vulnerability to past extreme climate events in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).



Source: Household Survey, 2019–2020.

Table 6.5 shows the ANOVA analysis output conducted to evaluate whether there was a statistically significant difference between different groups of vulnerable households with respect to the mean number of children ever born by a woman. Table 6.5 shows there was a statistically significant difference among the households living in the area hit by cyclones (F (2, *310*) = 7.222, p = .001).

Table 6.5 Households' vulnerability level to past extreme climate events and the fertility of women respondents in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Levels of household vulnerability to past extreme climate events	Mean number of children ever born			
	Cyclones		***Floods***	
	Mean	**St. Dev**	**Mean**	**St. Dev**
High	1.88	.892	4.00	1.819
Moderate	2.28	.970	3.64	1.928
Low	2.30	1.033	3.80	1.848
Levene Statistic	p = .140		p = .625	
ANOVA test: F and p-value	F (2, *310*) = 7.222, p = **.001**		F (2, *228*) = .493, p = **.611**	

Source: Household Survey, 2019–2020.

However, Table 6.5 does not make explicit where the differences were within the specific groups of households in relation to their levels of vulnerability to extreme climate events. The Tukey post hoc test, however, is able to reveal the differences, and the results of this test are presented in Table 6.6. They reveal that the mean number of children was statistically significantly higher for groups of "low" (2.30 ± 1.03, p= .003) and "medium" (2.28 ± .970, p = .024) vulnerability compared to the "high" (1.88 ± .892) group in Chadnimukha. In other words, in the cyclone–hit village, households of "high" vulnerability were less likely to have more children compared to households of "low" or "moderate" vulnerability. The extensive loss and damage experienced by such households from past cyclones were likely to be associated with increased household poverty and the migration of male members, both of which being key determinants that affect the fertility decisions of women. There was no statistically significant difference between the "low" and "medium" groups in Chadnimukha (p = .991).

Table 6.6 Tukey post hoc tests results of multiple comparisons of women's fertility by their household vulnerability in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

(A) Levels of household vulnerability to past extreme climate events	(B) Levels of household vulnerability to past extreme climate events	Mean Difference (A–B)	Std. Error	Sig.
Cyclones				
Low	Moderate	.021	.169	.991
	High	.418*	.125	**.003**
Moderate	Low	–.021	.169	.991
	High	.397*	.151	**.024**
High	Low	–.418*	.125	**.003**
	Moderate	–.397*	.151	**.024**
Floods				
Low	Moderate	.164	.268	.814
	High	–.195	.399	.876
Moderate	Low	–.164	.268	.814
	High	–.360	.387	.622
High	Low	.195	.399	.876
	Moderate	.360	.387	.622

Note: The mean difference is significant at 5%, and they are indicated in *bold*.
Source: Household Survey, 2019–2020.

6.6.1 A modelling approach to assess how households' vulnerability-related determinants affecting the fertility of women

Extreme climate events (e.g., cyclones or floods) are likely to affect households differently irrespective of the intensity and the areal extent of the event itself. For this study, it was assumed that the vulnerability of a household would vary by the type of extreme climate event(s) experienced by that household. In response to this vulnerability, households may use a number of strategies to cope with and adapt to the stress. Changing fertility intentions and decisions can be one such strategy for women. Generalised linear regression models were used to examine how the determinants of households' vulnerability influenced the fertility of women.

6.6.1.1 Definitions of variables related to the vulnerability of households

In the linear regression model, the independent variables were the dimensions of household vulnerability, calculated to serve as determinants of such vulnerability. This section describes how these determinants were calculated.

The *socio–demographic* dimension of household vulnerability was measured using the family dependency index (FDI), the ratio of the population aged under 15 and aged above 65 years to the working-age population (over 15 to below 65). A higher score in the FDI indicates greater household vulnerability to extreme climate events. Given the increasing risk of climate change and extreme climate events for agriculture in Bangladesh, rural households adopt diversified livelihood options to cope with the risks.

The *livelihood* dimension of household vulnerability was calculated according to the livelihood diversification index (LDI), which is formulated as the inverse of (the number of agricultural livelihood activities + 1) of livelihood activities; e.g. a household that farms, raise animals, and collects natural resources will have a livelihood diversification index=1/(3+1)=0.25; therefore, a higher LDI score indicates a lower number of livelihood activities. In addition to having an impact on vulnerability, the primary income source from which a household receives a majority of the total income can play a significant role in the well-being of that household. Since rural areas of Bangladesh have economies based on agriculture, income from agriculture can play a significant role in defining the adaptive capacity of a household to climate-related extremes, given that agriculture is sensitive to climate variabilities and associated risks. Therefore, it is important to calculate the agricultural income ratio in order to indicate the ratio of agricultural income out of the total income of a household.

As previously noted in Chapter 5, human health is sensitive to changing climate and extreme climate events, and such an impact can increase the vulnerability of households. The questionnaire asked respondents about their experience of death, disease, stress, and/or disability within their household: “Have any household members had any health issues in the 5 years (2014–2018) prior to 2019 for which they needed to consult a doctor or visit the hospital?” To calculate the *health* dimension of household vulnerability, the derived responses were coded as: 0 “no impact”, 1 “infant mortality”, 2 “severe diseases”, 3 “psychological distress”, and 4 “severe injury or physical disability”.

The questionnaire further asked about the assistance sought or received to assess the *social network* dimension of household vulnerability: if the household sought or received financial or non-financial assistance in the preceding 5 years (2014–2018) prior to 2019 from friends, relatives, the government, and/or non–government organisations when extreme climate events occurred or when facing economic difficulties, the responses were coded as: 0 “no assistance received”, 1 “friends or relatives”, and 2 “government or NGOs”.

Because crop production in Bangladesh is sensitive to climate variability and extreme climate events, households are more likely to witness increased vulnerability if they rely solely on agriculture as their major source of staple food. Failure to ensure a household’s food security can seriously affect the health of household members, and have particular adverse effects on reproductive health and child nutrition. Therefore, the questionnaire asked women whether agriculture is the primary source of the household’s staple food, and the derived responses were coded as: 0 “no” and 1 “yes”.

Other dimensions of household vulnerability, calculated to serve as determinants of such vulnerability are land area per capita (ha), years of schooling completed by household heads, and the ratio of time in minutes to travel to the nearest health facility during disaster times and other times of the year. The land area per capita (ha) is the total farm size of a household divided by its family size. Table 6.7 presents the descriptive statistics of the variable associated with each predictor, and Table 6.8 presents the results of the generalised linear models. The information provided in these tables is discussed in greater detail in Sections 6.6.1.2 and 6.6.2, respectively.

6.6.1.2 *A comparison of household vulnerability of survey respondents by village, based on descriptive statistics*

To more closely examine and compare the findings regarding the vulnerability of households in Chadnimukha and Lamagaon, this section highlights the findings presented in Table 6.7. According to these descriptive statistics, two-thirds of the households surveyed in Chadnimukha (cyclone-affected area) rely on wage labour, either agriculture- or non-agriculture-based, as their primary source of income. It is difficult to make a living farming or homestead gardening, because agricultural production in the region is sensitive to soil and water salinity: the growing number of storms in the region are associated with increased damage to dams, which then allow salt water to enter the farmland and affect crop production, particularly the rice varieties that are the primary food of the community.

Table 6.7 Households' vulnerability characteristics, in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Determinants	***Cyclones***	***Floods***
Income sources (%)		
Farming	16.9	35.5
Fishing	16.0	42.4
Agricultural wage labour	40.6	13.9
Non–agricultural wage labour	26.5	8.2
Health shock (%)		
No impact	42.5	23.8
Infant mortality	15.0	20.3
Severe diseases	19.2	16.9
Psychological distress	10.5	20.3
Physical injury or disability	12.8	18.6
Assistance received (%)		
No assistance received	44.4	43.3
Friends or relatives	29.4	28.1
Government and NGOs	26.2	28.6
Agriculture major source of staple food (%)		
No	64.2	49.8
Yes	35.8	50.2
Family dependency index [mean (SD)]	.939 (.663)	1.09 (.795)
Livelihood diversification index [mean (SD)]	.329 (.117)	.344 (.120)
Land area per capita (ha) [mean (SD)]	.048 (.047)	.052 (.055)
Years of schooling of household head [mean (SD)]	4.2 (4.06)	3.04 (3.53)
Ratio of agricultural income to total income [mean (SD)]	.700 (.243)	.575 (.177)
Ratio of time (minutes) to travel to the nearest health facility during disaster times and other times of the year [mean (SD)]	1.64 (.846)	.741 (.051)
Number of extreme climate events [mean (SD)]	2.5 (1.2)	2.7 (1.4)

Source: Household Survey, 2019–2020.

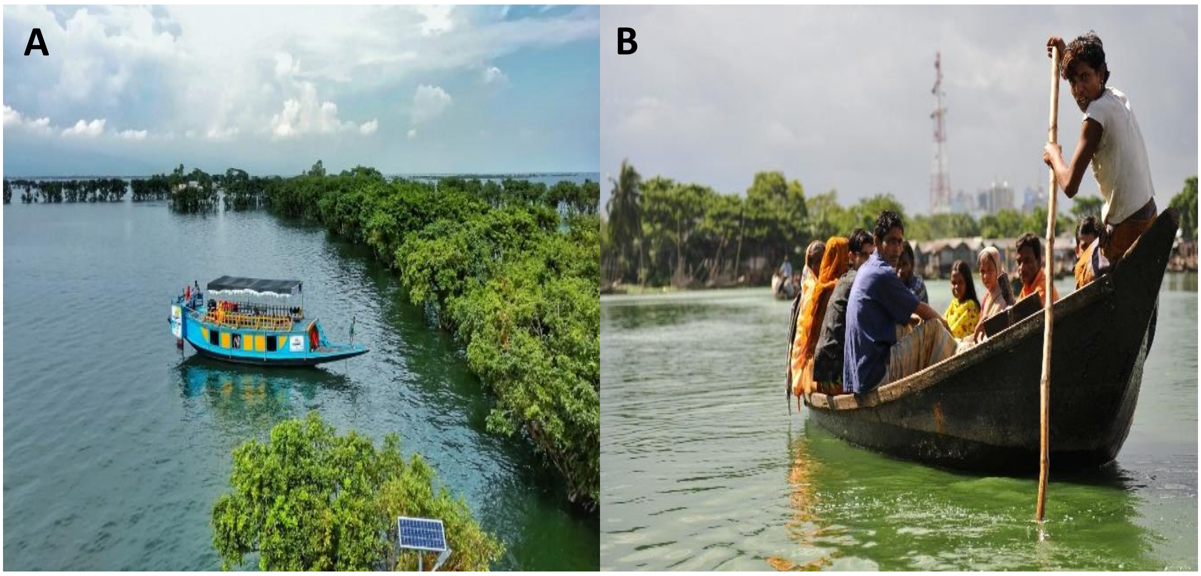
In Lamagaon (flood-affected area), more than one-third of households depend on agriculture and two-fifths on fishing for their primary source of income. The region is a wetland area with a diversity of fish species, and the land often benefits from floods, becoming more fertile for crop production. Landless families in the flood-hit village can depend on agricultural wages from harvesting rice paddies in the dry season. Agriculture was the primary food source for the half of households in Lamagaon (flood-affected area) and more than one-third of that in Chadnimukha (cyclone-affected area), indicating that they may face severe food insecurity if their food production was affected by extreme climate events.

It was found that the families of survey respondents living in the flood-affected area had experienced a greater number of health effects than those in the cyclone-affected area. While two-thirds of the families surveyed in the flood-hit village reported having experienced infant mortality, serious illness, stress or severe trauma, and physical disability in the last five years, just over half of the respondents in the cyclone-hit village had experienced such health impacts, and a significant percentage (42.5%) reported that cyclones had had no health effects. Floods are associated with increased infant mortality during the flood season, waterborne diseases resulting from drinking and using contaminated water, psychological stress due to crop damage and loss, physical injury or disability caused by the floods, and a disruption of access to health benefits.

Differences across a number of other determinants were less noteworthy. For example, it was found that there was no significant difference between cyclone- and flood-affected areas regarding the number of families receiving assistance. Receiving financial or non–financial support from friends, relatives, government and non-government organisations can both help families cope with stress during times of crisis or after cyclones and floods and help them build adaptive capacity and resilience. The livelihood diversity index suggests that families in both villages have adopted multiple livelihood options to adapt to the changing environment. The per capita land area (ha) was slightly higher for the population living in flood-hit village than in the cyclone-hit village, but perhaps not high enough to make a significant difference in household vulnerability. The average years of schooling completed by the heads of the families in both study sites indicate that most did not complete primary school, and a small number had received higher secondary schooling, mainly in the cyclone-hit area. While the difference is relatively small, heads of respondent families in the cyclone-hit village had more years of schooling than did those in the flood-hit village. It was also evident from Table 6.7 that households surveyed in the cyclone-affected village had higher incomes from agriculture, particularly through agricultural wage labour, compared to those in the flood-affected village.

One final and significant difference can be observed in Table 6.7: the ratio of the time in minutes to travel to the nearest health facility using the standard mode of transportation (e.g., walk, boat, auto-rickshaw) at normal times and during extreme climate events. Results for this predictor indicated that respondents in the cyclone-hit village spend more time travelling during disaster times, while respondents in the flood-hit village can actually reach health facilities more quickly during the flooding season than the dry season. This is because the people in the flood-hit village use manual or engine-driven country boats (locally called *nouka*) during the flood season, and can avoid the long routes that can be required to reach their destinations. Plate 6.1 shows two typical kinds of boats used to transport tourists and passengers: tourists boats (A) are relatively large and require more than two boatmen to operate them, and passenger boats (B), usually driven by one or two boatmen, might be tiny or large. The existing road transportation system in flood-prone areas can only be used during the dry season, because roads are submerged during the rainy season and necessitate the use of water vehicles as the primary mode of transportation.

Plate 6.1 Boats used for the transportation of tourists and passengers in riverine Bangladesh.



Notes: **A**. Large engine-driven boat to transport tourists and sometimes passengers in *Tangaor Haor* in *Tahirpur* district. **B**. A boatman drives a small boat to transport passengers a shorter distance to cross a river in Bangladesh.
Source: Internet (A. https://www.tbsnews.net/bangladesh/tourism–flourishes–houseboats–tanguar–haor–307171 B. https://www.flickr.com/photos/asiandevelopmentbank/8424860439)

6.6.2 Households vulnerability determinants and fertility of women: results of generalised linear modellings

Generalised linear modellings were used to explore how the determinants related to household vulnerability to extreme climate events influenced the fertility of respondents in the cyclone-hit village and in the flood-hit village (Table 6.8).

Table 6.8 Generalised linear modelling: parameter estimates of children ever born with associated households' vulnerability related determinants in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Determinants	**Coefficient**	
	Cyclones	***Floods***
Income sources		
Farming (ref.)		
Fishing	–.112	–.412
Agricultural wage labour	–.169	–.524
Non–agricultural wage labour	.081	–.756*
Health shock		
No impact (ref.)		
Infant mortality	.317**	–.457
Severe diseases	1.057***	1.086***
Psychological distress	.564***	.207
Physical injury or disability	.050	–.063
Assistance received		
No assistance received (ref.)		
Friends or relatives	–.205*	.274
Government and NGOs	–.021	.416
Agriculture major source of staple food		
No (ref.)		
Yes	.271**	–.082
Family dependency index (FDI)	.283***	–.120
Livelihood diversification index (LDI)	.354	1.550
Land area per capita (ha)	–3.067***	–2.343
Years of schooling of household head	–.032***	–.141***
Ratio of agricultural income to total income	–.316	–.111
Ratio of time (minutes) to travel to the nearest health facility during disaster times and other times of the year	–.088	–1.636
Chi–square statistics (likelihood ratio)	141.116***	56.039***
Log–likelihood	–361.066	–445.153
AIC	758.131	926.305
BIC	825.563	988.269

Note: *** p < .01, ** p < .05, * p < .10.
Source: Household Survey, 2019–2020.

Model fitting information–based on the AIC and BIC values in the Table 6.8–suggests that households' vulnerability determinants fit better to explain fertility variations in the cyclone-hit village than to explain such variations in the flood-hit village. Moreover, out of ten determinants, six for the cyclone-hit village (health shock, assistance received, agriculture as primary food source, FDI, land area per capita, and years of schooling completed by household heads) and three for the flood-hit village (primary income sources, health shock, and years of schooling completed by household heads), significantly explain the fertility variations.

In the cyclone-hit village, the fertility of women increased if households reported infant mortality, severe diseases, and psychological distress. Households with severe diseases and psychological distress of adult members may realise the importance of having a large family where other members could nurse or provide needed support to the members with illness, diseases, distress, and disability.

In the cyclone-hit village, households receiving assistance from friends or relatives in times of crisis were less likely to have more children. It has been found that local social capital resources and networks play an important role in community resilience and recovery from the adverse effects of extreme events (Hawkins & Maurer, 2010; LaLone, 2012). Moreover, in the immediate aftermath of a cyclone in Bangladesh, affected families rely on the bonding network (e.g., relationships with relatives and friends) and the bridging network (e.g., relationships with neighbours and friends) to deal with the crisis, as the agencies that assist take at least a few days to reach the affected area (Islam & Walkerden, 2014). Households with improved adaptive capacity and resilience to a disaster indicate their improved socio-economic conditions, affecting the decisions to limit the number of children.

Households in the cyclone-hit village were found to have an increased number of children if agriculture was their primary source of staple food. This indicates that farm households relying on agriculture as their crucial source of staple food were more likely to have more children. Women in the cyclone-hit village were more likely to have more children with an increase in the family dependency index. However, land area per capita was negatively associated with women's fertility in both areas, and was especially significant in the cyclone-hit village. Women were less likely to have more children with an increase in the land area per capita (ha). According to the land-security hypothesis proposed by Stokes and Schutjer (1984), the land is considered a substitute for children for parental old-age security. If so, land ownership or increasing land size should reduce the value of children as a source of parental security in old age, lowering the motivation for additional children. Years of schooling of household heads were significantly negatively associated with women's fertility: women were less likely to have more children with an increase in years of schooling completed by household heads.

The primary income source of households was negatively associated with the fertility of women in the flood-hit village, suggesting that households which extensively rely on non-agricultural wage labour (e.g., migration of male members), and are more likely to experience a decline in fertility than those that rely on farming. In other words, households with farming as a primary income source had more children, indicating that farm households demanded an increased labour force for agricultural activities and were likely to benefit from a large family. Moreover, severe diseases of household members influenced women to have more children, and a higher schooling of household heads influenced women to limit their number of children.

As a sensitivity analysis, separate models were run using the data collected from the surveys undertaken by younger women aged 18 to 34 years (see *Table C9, Appendix C*): a very similar pattern of results was observed. The limited sample size of older women respondents (35–49 years) living in the cyclone-hit village (N=99) and the flood-hit village (N=74) did not allow for further sensitivity analysis.

6.7 A modelling approach to assess the relationship between extreme climate events-related determinants and the fertility of women

Generalised linear modelling was used to explore the effects of socio-demographic and extreme climate events-related determinants on the fertility of women. Two models were developed. Model 1, described in 6.7.1, includes only socio-demographic determinants, and model 2, described in 6.7.2, considers determinants related to extreme climate events along with the determinants of model 1. Table 6.10 presents the results of the generalised linear modelling (models 1 and 2) to estimate the number of children ever born by socio-demographic characteristics and determinants related to extreme climate events for the cyclone-hit village and the flood-hit village. A comparison of models 1 and 2 can illuminate whether and how the model fit improves by including the determinants associated with extreme climate events. AIC and BIC were used to assess the model selection; smaller values indicate a better model fit. The dependent variable is the number of children ever born and independent variables are socio-demographic characteristics and determinants related to extreme climate events, which were discussed earlier in Chapter 4 (refer to Tables 4.7, 4.8).

Table 6.9 Generalised linear modelling: parameter estimates of children ever born with associated socio-demographic and extreme climate events-related determinants in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Determinants	*Cyclones* Coefficient		*Floods* Coefficient	
	Model 1	**Model 2**	**Model 1**	**Model 2**
Socio-demographic determinants				
Age				
18–24 (ref.)				
25–34	.806***	.553***	1.550***	.855***
35–49	1.161***	.610***	2.913***	1.782***
Education				
No schooling (ref.)				
Primary school	.134	.121	–.417*	–.026
Secondary school	.028	.062	–.656***	–.317*
Higher secondary school	.109	.220	–.516	–.143
Age at marriage				
Less than 18 years (ref.)				
18 years or over	–.178*	–.047	–.833***	–.297
Contraceptive use				
No (ref.)				
Yes	.361***	.070	.680***	.316**
Health				
Poor (ref.)				
Fair	.070	.174*	.143	.077
Good	.204*	.166*	–.295	–.165
Extreme climate events-related determinants				
Timing of first birth with an extreme climate event				
There was no extreme climate event (ref.)				
Before an extreme climate event		–.345***		–.124
During or after an extreme climate event		–.377***		–.365**
Migration after an extreme climate event				
No (ref.)				
Yes		–.030		–.237
Households' vulnerability to past extreme events				
Low (ref.)				
Moderate		.090		.094
High		–.237***		.124
Frequency of extreme climate events				
One (ref.)				
Two		–.625***		.437*
Three and more		–.658***		1.245***
Perceived risk of child death with extreme events				
No (ref.)				
Yes		.099		.763***
Failure to access contraceptives with extremes				
No (ref.)				
Yes		.663***		1.279***
Gender preference with extreme climate events				
Daughter (ref.)				
Son		.199***		–.119
Chi–square statistics	100.091***	290.011***	155.673***	300.199***
Log–likelihood	–381.578	–286.618	–395.336	–323.072
AIC	785.157	615.236	812.671	688.145
BIC	826.365	693.907	850.538	760.436

Note: *** p < .01, ** p < .05, * p < .10.

Source: Household Survey, 2019–2020.

As previously noted, models 1 and 2 are described in greater detail in the following two sections.

6.7.1 Socio–demographic determinants and fertility: results of generalised linear modelling (*model 1*)

Five socio-demographic variables—the age of women, education, age at marriage, contraceptive use, and health—were considered for model 1. Comparing model 1 for the cyclone-hit village with that of flood-hit village, the model fit improves with the lower log-likelihood, AIC, and BIC. Of the five socio-demographic determinants, the education of respondents for the cyclone-hit village and their health for those of the flood-hit village did not significantly explain the variations in fertility. As expected, age was positively associated and age at marriage was negatively associated with the number of children ever born in both villages. Those women in both areas using contraceptives were likely to have had more children, indicating that they had achieved their fertility goals and were using contraceptives in order to stop childbearing. Education was deemed to be a significant determinant of fertility, as in the flood-hit village, respondents with more education had less children. Good health was significant for respondents in the cyclone-hit village, as, because of their health, they were more likely to give birth to a greater number of children than their counterparts with poor health.

6.7.2 Extreme climate events-related determinants and women's fertility: results of generalised linear modellings (*model 2*)

Model 2 reveals that model fit improves significantly for both areas when determinants related to extreme climate events are taken into consideration with those determinants considered for model 1. This indicates that extreme climate event determinants are significant to explain noted variations in fertility and can add significant value to the established fertility determinants. The AIC and BIC values suggest that the considered determinants in model 2 are more significant to explain the fertility variations of respondents in the cyclone-hit village than those in the flood-hit village. The coefficient directions of socio-demographic determinants in model 2 were similar to those in model 1; however, their magnitude and the level of significance changed marginally for a number of determinants. Age at marriage was not significant in model

2 for both study areas. Moreover, contraceptive use was a non-significant predictor in model 2 for the respondents in the cyclone-hit village.

Of the seven extreme climate event-related determinants, five for the cyclone-hit village (timing of first birth, household vulnerability to past extreme climate events, frequency of extreme climate events, failure to access contraceptives, and gender preferences) and four for the flood-hit village (timing of first birth, frequency of extreme climate events, risk of child death, and failure to access contraceptives) were significant to explain the variations in the number of children ever born.

Timing of first birth with an extreme climate event was significant for both areas: women had less children if the first birth was either before, during, or after a cyclone or a flood than women who mentioned no extreme climate events associated at the time of birth. It has been found that women with gynaecological problems and pregnancy face increased suffering before, during, or after an extreme climate event in Bangladesh (Rezwana, 2018). While Zilversmit et al. (2014) suggested that the negative effects of an extreme climate event on postpartum health and the health of newborns could be lessened through the development of an emergency plan, this study identified no special arrangements or plans in Bangladesh for the evacuation of pregnant women or nursing mothers to take shelter during cyclones or floods. During the focus group discussions, some male participants stated that they prioritised the pregnant women during the evacuation process, as they are considered the most vulnerable group in an extreme event. However, pregnant women needed to take shelter with other villagers irrespective of age, gender, or vulnerability status in a shared multi-purpose building used as a cyclone shelter. Undoubtedly, these women typically have to sacrifice their privacy or honour in such a situation and could get injured or lose their infants or even their lives. This experience could shape a perception of extreme climate events that could, in turn, negatively influence their childbearing intentions and limit their number of children.

In the cyclone-hit village, respondents had a higher risk of having a limited number of children if they perceived their households had been *highly* vulnerable to cyclones in the past 10 years (2009–2018) than their counterparts perceiving their households to have a *low* level of vulnerability. Increased loss and damage of such households from past cyclones are likely to be associated with increased household poverty; these households and more likely to experience the migration of male members, which can affect the fertility decisions of women. Households with limited adaptive capacity that are affected by frequent cyclones have to spend most of their financial or human resources to repair the damaged houses, as well as to recover from the economic loss and damage and undergo sustained poverty. Consequently, the economic hardship of such households may influence couples to limit their number of children. Moreover, it can be assumed that adult members of a household (e.g., male head and active female) that experiences devastating destruction must expend a great deal of time and energy after a cyclone repairing the damage.

The frequency of cyclones or floods was found to have different impacts on the fertility of women. Respondents had less children if they had experienced a greater number of cyclones. In contrast, respondents had more children if they had experienced a greater number of floods. Increasing frequency of floods can directly (e.g., drowning during floods) or indirectly (e.g., through morbidity) increase the risk of child death. Respondents in the flood-hit village had more children if they perceived that floods carried the risk of child death; their counterparts who did not perceive the same risk to be associated with cyclones had fewer. Therefore, an increasing number of children may have been considered to be an effective insurance mechanism against the increased risk of child mortality with floods.

Respondents in both study areas had more children if they had failed to access contraceptives due to extreme events. Around 25 percent of respondents in both study areas reported that they had failed at least one or more times to get contraceptives during a climate event that limited their access. Qualitative findings also revealed how failing to access contraceptives impacted fertility (refer to section 6.8.3). Gender preference was also significant for respondents in the cyclone-hit village; these women had more children if they preferred sons who they felt could assist with the recovery process after cyclones.

As a sensitivity analysis, separate models were run using the data collected from the surveys undertaken by younger women aged 18 to 34 years (see *Table C10, Appendix C*). A very similar pattern of results was again observed.

6.8 Discussion

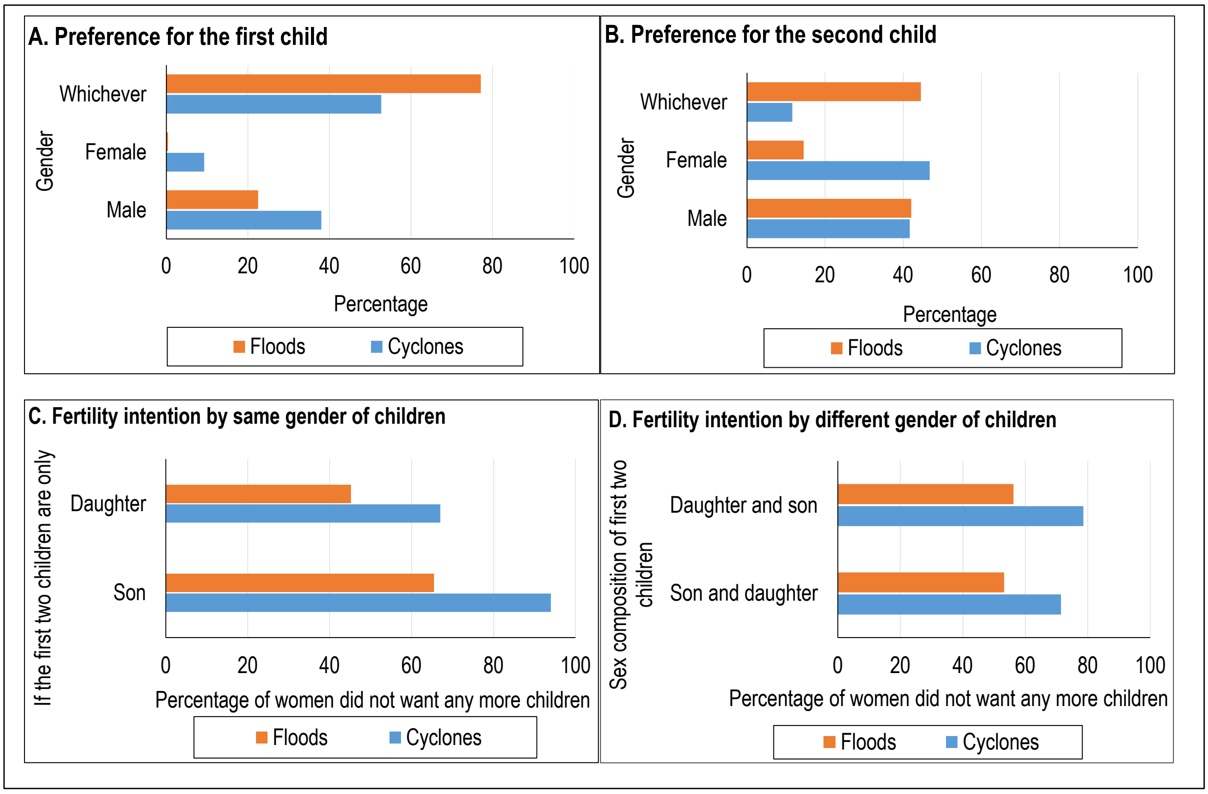
This section delves more deeply into the ways in which determinants associated with extreme climate events affect the fertility of women by triangulating both the quantitative and qualitative information gathered and analysed over the course of this research. This section provides evidence that demonstrates that extreme climate events influence gender preferences and the risk of child mortality affects the fertility of women. Extreme climate events also adversely affect access to contraceptives, leading to unplanned or mistimed pregnancies and subsequent births. Another possible effect of extreme climate events—hunkering down during disaster times—can have the potential to increase the coital frequencies among couples and, in turn, fertility. The physiological effects of extreme climate events are additional critical determinants affecting the fecundity and fertility of women. Finally, a connection between migration, marriage, and birth and extreme climate events is demonstrated.

6.8.1 Extreme climate events and preference for sons

As part of its investigation, this research sought to determine whether the adverse impacts of a climatic event could influence parents in rural settings of Bangladesh to think about whether it would be better to have sons or daughters in the family. Figure 6.4 shows the reported sex preferences given four different family contexts, based on the adapted use of the following traditional measures: the *son preference ratio* (SPR) and the *desire for balance ratios* (BR) (Malhi, 1995; Rai et al., 2014). Techniques to measure the SPR and BR were proposed in a longitudinal study in Taiwan (Chang et al., 1987) and considered for use in this study. However, these measures could not be followed rigorously to derive ratios, due to data limitations associated with small samples. To overcome these limitations, the alternative approach of triangulating quantitative and qualitative information was taken to reveal son preference among household survey respondents in both the cyclone-hit and flood-hit villages.

Figure 6.4 A shows that, while the majority of respondents in both villages did not have any sex preference for their first children, just under 40 percent in the cyclone-hit village and just over 20 percent in the flood-hit village wanted to have a male child at their first birth. In contrast, the sex preference for the second child indicates that the majority of the respondents in the cyclone-hit village had a clear preference, either for a girl (47%) or a boy (42%), and the majority of those in the flood-hit village either wanted a boy child (42%) or had no preference (45%) (Figure 6.4 B). During their in-depth interviews, women in the cyclone-hit village typically reported that their ideal number of children was two, and that they aspired to have a boy and a girl. Many respondents in the flood-hit village did not have any preference for their first and second children, which could be due to their higher overall fertility; they may tend to express sex preferences after the first two births.

Figure 6.4 Women respondents with a gender preference for their first and second children, and fertility intentions by sex composition of current children, in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).



Notes: (A) Preference of sex of the first child. (B) Preference of sex of the second child. (C) Fertility intention if the first two children are of the same sex. (D) Fertility intention if the first two children are of different sex.
Source: Household Survey, 2019–2020.

Son preference was further examined by comparing the number of women who already had two children of the same sex or of different sexes and their intentions not to have any more children (Figure 6.4, C, D). If their first two children were sons, more respondents in both villages (94% in the cyclone-hit village, and 66% in the flood-hit village) indicated that they did not want to have any more children; if the first two children were daughters, a smaller percentage of respondents did not want additional children. In other words, respondents from both villages were more likely to intend to have more children if the first two were daughters. Compared to those in the flood-hit village, more respondents in the cyclone-hit village, either with sons or daughters as first/second children (72% if the order was son-daughter, 79% if the order was daughter-son), did not want to have any more children. There could be an emerging preference for gender balance among respondents that have been further examined by the different sex composition of the first two children and the percentage of women who did not want any more children. Figure 6.4 D indicates that respondents in both villages who already have one son and one daughter were less likely to want additional children. This finding is concordant with a recent study in Bangladesh that revealed that women were less likely to have a third child if the first two children were sons or were one son and one daughter than were women whose first two children were daughters (Asadullah et al., 2021).

In summary, it can be implied that, in the study villages, fertility intentions determined after the births of the first two children depended on whether the parents had at least one son. Findings indicate a clear preference for sons or for gender balance over daughters in both villages. That son preference could be linked to the benefits associated with having a son (or sons) who can help parents during extreme climate events and other emergencies. As part of the exploration of this topic, focus group discussions were held with men about the advantages and disadvantages of having more children, particularly sons, in respect to the effects of extreme events. Women, during in-depth interviews, also shared their opinions about the advantages and disadvantages of having children in general and of having boys and girls.
For example, as part of the focus group discussion, a 37-year-old farmer in the flood-hit village expressed his opinion that having a number of children, both sons and daughters, could help households in many ways during disaster times.

> *Having more children is beneficial since they can give their parents a hand during crises. A son can go fishing with his father or collect straw to repair houses. He can bring medicine and shop for groceries. If the damage to houses and properties is severe, the son is an excellent helping hand to his father. In contrast, a daughter can cooperate with her mother in doing household chores. Moreover, she can collect fodder and water for the household, wash kitchen utensils and clothes, and repair damaged fences and houses. (Participant 7, FGD, flood-hit village of Lamagaon)*

A primary school teacher aged 34 years in the flood-hit village stated that sons have more to offer than daughters.

> *A son can contribute more than a daughter during an emergency or a flash flood. Daughters can do household activities; they do not usually go outside without adult male assistance and are physically less capable of doing work requiring heavy physical*

labour and mobility. In coping with and recovering from the stress of the flood, a greater number of sons in a household can help, since they are physically stronger and more courageous and can help move family members and assets to safer places and repair damaged houses and properties. A younger son of at least ten years can operate a boat during an emergency. Having sons in a household is insurance against the adverse impacts of floods. (Participant 6, FGD, flood-hit village of Lamagaon)

During her in-depth interview in the cyclone-hit village, a 32-year-old woman with 4 children said that sons, at all stages of an extreme climate event, could help a household in several key ways:

Sons can help in many ways before, during and after cyclones. Before a cyclone, they can help move household pieces and family members to safer places or cyclone shelters. They can also repair the damaged houses and properties and earn money to help household in buying food and groceries in crises after a cyclone. In contrast, daughters cannot help us; instead, we need to help them. (Participant 1, IDI, cyclone-hit village of Chadnimukha)

Studies have shown that fertility decisions of Bangladeshi women are still shaped by their preference for sons (e.g., Asadullah et al., 2021; Kabeer et al., 2014; Rahman, 2018). Biddlecome et al. (2005) argued that, when the desire for labour (especially male labour) rises, men and women prefer to have a larger number of children. However, a number of participants in this study, particularly those in the cyclone-hit village, suggested that having more children was also seen as a disadvantage for households. Some focus group participants and women engaged in the in-depth interviews in Chadnimukha perceived that younger children of less than ten years of age in households were more of a hindrance than a help. A 45-year-old male high school teacher in the cyclone-hit village exemplified this opinion during a focus group discussion. He said:

Young children cannot help us; instead, parents need to help their young children move to safe places after receiving the cyclone warning. Households with younger children who cannot swim are more vulnerable to the injury and death induced by cyclonic *storms and the floods that follow storms. (Participant 17, FGD, cyclone-hit village of Chadnimukha)*

Having this perception would lead women to have fewer children and limit their future intention of having more children in quick succession.

6.8.2 Extreme climate events, risk of child mortality, and fertility

A considerable body of theoretical work (Cain, 1981; Finlay, 2009; Frankenberg et al., 2015; Nobles et al., 2015; Pörtner, 2008) shows that fertility levels interact with child mortality through two processes: (1) exposure to mortality outside one's own family and (2) experiencing the death of one's own child. In both cases, fertility tends to rise.

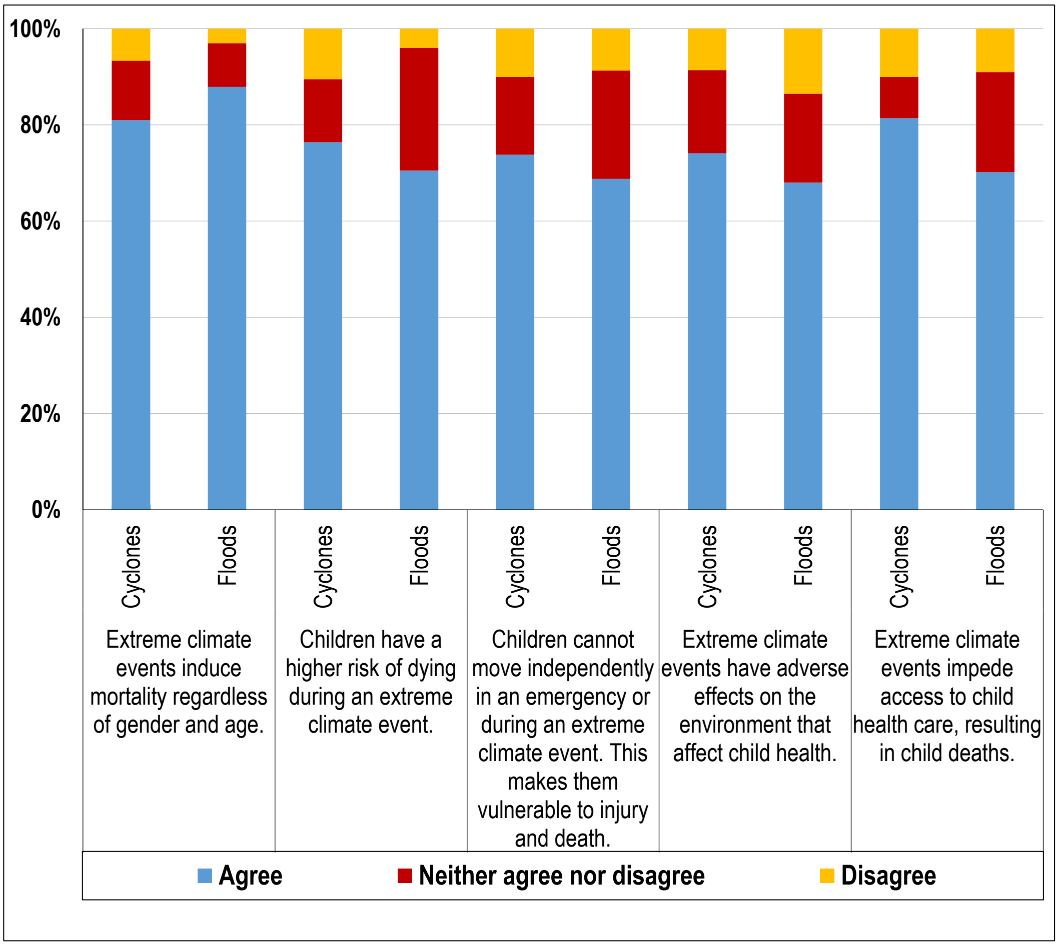
Exposure to child mortality in an extra-familial context has been seen to fuel a concept of fertility as *insurance*: parents have more children than they actually want because they expect that some will not survive (Cain, 1981; Pörtner, 2008). It is more likely that parents in areas with an increased incidence of child mortality will have such an expectation. Because extreme climate events are associated with increased economic and non-economic loss and damage (Bhowmik et al., 2021), including but not limited to fatalities, it can be expected that populations living in disaster-prone areas will perceive a greater risk of child mortality.

Apart from this insurance mechanism, this concept of insurance can also be applied more broadly: an increase in women's fertility may represent a risk-sharing mechanism operating at the community level, whereby the next generation of children are seen as a benefit to community members. Given the greater risk of child mortality in communities that are vulnerable to extreme climate events, it can be assumed that populations within such communities will prefer to have a greater number of children, particularly more sons, to cope with disasters and minimise mortality and loss and damage at the community level. Whether the preference to have additional children is intended to benefit the family or the community, increased fertility can clearly serve as an insurance mechanism in an area vulnerable to extreme climate events with few alternative sources of insurance (Cain, 1981).

Meanwhile, experiencing the death of one's own child may prompt a couple to attempt to conceive in order to replace the lost one. An excellent example that illuminates this *replacement theory* is the 2008 Wenchuan earthquake in China, after which the state allowed parents who had lost their only child to have another (Qin et al., 2009). Nobles et al. (2015) found that, in Indonesia, women who had lost one or more children in the 2004 tsunami were more likely to want to have additional children, and women who had had no children before the tsunami "initiated family-building earlier in the communities where tsunami-related mortality rates were higher" (Nobles et al., 2015, p. 15).

This research has found that respondents living in both cyclone-hit and flood-hit villages reported having perceived that the adverse effects of extreme climate events increase the risk of child death. As shown in Figure 6.5, the percentage at which survey respondents agreed to statements in the survey on the risk of child death suggest that they clearly perceived the risks.

Figure 6.5 Perceptions of child mortality due to extreme climate events in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).



Source: Household Survey, 2019–2020.

It was found that respondents in both villages were more likely than not to perceive that, while cyclones or floods can cause deaths irrespective of gender and age, children were at higher risk. Notably, respondents in the cyclone-hit village were more likely than their counterparts in the flood-hit village to identify the risk of child deaths to be associated with their dependency on adults during emergency (73.8%), the disease and morbidity resulting from the effects of the event on the environment (74.1%), and hindered access to health facilities due to the event (81.4%). It is worth noting that drowning has been found to be a leading cause of child death in Bangladesh for children up to 9 years of age (Rahman et al., 2009) and for children aged 1 to 17 (Hossain et al., 2015). Moreover, rural areas of the country have a higher child drowning rate than is the case in urban areas (Hossain et al., 2015).

As noted, it has been argued that women tend to bear more children as insurance against the adverse effects of extreme climate events or hazardous environments (Cain, 1981, 1983, 1986; Frankenberg et al., 2015) or to replace the lost ones (Finlay, 2009). Results from this study (Table 6.12) reveal that the number of child deaths was comparatively higher in the flood-hit village than in the cyclone-hit village. For example, more than one-third of household survey respondents in Lamagaon reported the death of at least one child during their reproductive span, whereas less than one-fifth of the respondents in Chadnimukha had had this experience. An ANOVA test was run in order to determine whether the higher fertility of women in the flood-hit village could be attributed to the higher child mortality in that village; the ANOVA test examined the mean number of children alive between women who experienced child mortality and who had not.

Table 6.10 Number of children alive to women respondents by their experience of child death in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Characteristics	**%**		**ANOVA test results Number of children alive**			
	Cyclones	***Floods***	***Cyclones***		***Floods***	
			Mean (SD)	**F (p–value)**	**Mean (SD)**	**F (p–value)**
Experience of child mortality						
Yes	16.6	36.8	2.08 (.882)	3.617	3.62 (1.54)	9.68 (**.002**)
No	83.4	63.2	1.84 (.812)	(.058)	2.99 (1.47)	

Source: Household Survey, 2019–2020.

The ANOVA test results revealed a significant difference between the respondents from the two villages: survey respondents in the flood-hit village who had experienced the death of a child had more children still alive than those who had not lost a child, indicating that the rise in fertility could be explained as an insurance mechanism or a replacement effect.

The findings of in-depth interviews also revealed that increased fertility of women was more likely to be associated with child mortality, particularly in the flood-hit village. Respondents were found to have had a higher number of children if they had experienced at least one child death. During an in-depth interview in flood-hit village, a woman aged 35 years who had five children said that:

> *Child mortality is ubiquitous in our villages or surrounding villages affected by floods, mainly due to drowning. I had lost two children–two sons. I wanted to have only two or three children; however, I ended up giving birth to five children. (Participant 2, IDI, flood-hit village of Lamagaon)*

Another woman aged 30 years with 3 children in the flood-hit village said:

> *After marriage, I discussed with my husband the number of children we wanted, and we decided on two. I had lost three children–two daughters and a son. If I had known the risk of child loss at that time, I would have decided to have more than two children. However, I ended up reaching my fertility goals with three kids–one son, and two daughters. (Participant 3, IDI, flood-hit village of Lamagaon)*

Respondents in the cyclone-hit village, whether they experienced child mortality or not, were less likely to have more children. The ANOVA test results in the cyclone-hit village did not show a significant difference in the number of living children between groups of women who had experienced child mortality and those who had not. It could be, instead, that exposure to deaths in general due to cyclonic storms and adverse environments may have induced lower fertility in women in Chadnimukha. Agadjanian and Prata (2002) found (Agadjanian & Prata, 2002) that, after a disaster, women practiced voluntary birth control due to dire experiences and worries about the probability of another disaster, and that this lowered fertility. Witnessing the deaths of family members and friends may also induce psychopathologies (Neria et al.,

2008) that reduce all of the following: the desire to have children, coital frequency, relationship quality, and a woman's physiological capacity to carry a child to term (Parker & Douglas, 2010).

6.8.3 Extreme climate events, access to contraceptives, and fertility

Table 4.11 reported the modern and traditional contraceptive methods used by survey respondents from Chadnimukha and Lamagaon. Findings from this study suggest that respondents from both villages regularly failed to access contraceptives after devastating climate-induced extreme events. Cyclone Aila hit a number of coastal areas of Bangladesh in 2009 and induced massive loss and damage to infrastructure including local community hospitals and family planning facility services. During their in-depth interviews, many women from Chadnimukha reported that they had been unable to access maternal and child health facilities after this event. Specifically, women did not receive the free contraceptives from the local community clinics (to which they usually had access) for several months after Cyclone Aila, and, for some, this resulted in an unintended pregnancy. This interruption to family planning services has been associated with other extreme events in other parts of the world. For example, women were found to reduce their visit to family planning clinics and use of birth control methods in the USA after Hurricane Katrina in 2005 (Kissinger et al., 2007) and Hurricane Ike in 2008 (Leyser–Whalen et al., 2011).

A 32-year-old woman with 4 children who participated in an in-depth interview in the cyclone-hit village shared her experience:

> *After Cyclone Aila in 2009, my husband and I were in a temporary shelter for several weeks. We had a baby in 2010. However, we had not intended to have another child. The previous doses of the oral contraceptive pill had been completed [before the cyclone], and I failed to get the following doses. There was no available oral pill stored in the community clinic or with the family welfare assistants. All necessary contraceptives and other drugs stored in the community clinic had washed away during the cyclone. (Participant 1, IDI, cyclone-hit village of Chadnimukha)*

As this respondent explained, women in both villages typically cannot access contraceptives from local family planning clinics or other potential sources during extreme climate events, as these events cause damage to community clinics and the resources (e.g., contraceptives and essential drugs) they offer. Moreover, in-depth interviews revealed that the Family Welfare Assistants (FWAs) also cannot reach villagers due to the disruption of transports to distribute contraceptives. In such circumstances, women or their partners tend to count on the unreliable withdrawal method or condoms to avoid pregnancy in place of the regular oral pill. Condoms can usually be collected by men a few days after a climatic event, from local sources such as pharmacies, grocery shops, or nearby clinics, to avoid unplanned pregnancies. It should be noted that women from both villages, during in-depth interviews, reported that their partner used condoms for the days following an extreme climate event if their current doses of contraceptive were over and they were unable to access a new course of pills immediately.

To gain a better understanding of the impact of extreme climate events on the contraceptive use of the withdrawal method and condoms, household survey respondents were asked, first, whether they had ever used these methods, and, next, when they used them. Findings reported in Table 6.13 show that around 28 percent of respondents in the cyclone-hit village and 7 percent in the flood-hit village had used a condom. Moreover, approximately 32 percent of respondents in the cyclone-hit village and 21 percent in the flood-hit village had used the withdrawal method. Regarding when they used condoms, 71 percent of respondents in the cyclone-hit village said that their husbands used this option on the days following cyclones. In contrast, it was reported by 75 percent of respondents in the flood-hit village that they had utilised condoms at various times when other options were unavailable. The findings indicate that withdrawal is the most common coping method during disaster times, with 95 percent and 98 percent respondents in the cyclone-hit and flood-hit villages, respectively, having used this method at that time. It is worth noting that the length of a *disaster time* can vary, from hours to days. Disaster time in a cyclone-hit village starts when households prepare to evacuate after receiving the first warning and return home after the area has been declared safe. In a flood-hit village, the disaster time lasts as long as it takes for the dangerous floodwaters to recede to a safe level.

Table 6.11 Condoms and withdrawal use and timings in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Characteristics	**% (N)**	
	Cyclones	***Floods***
Ever tried methods		
Condom	27.79 (87)	6.92 (16)
Withdrawal	31.62 (99)	21.21 (49)
Timing of condom use		
Anytime when other options are unavailable	12.64 (11)	75 (12)
During extreme climate events	16.09 (14)	/
After extreme climate events	71.26 (62)	25 (4)
Timing of withdrawal use		
Anytime when other options are unavailable	5.05 (5)	2 (1)
During extreme climate events	94.95 (94)	98 (48)
After extreme climate events	/	/

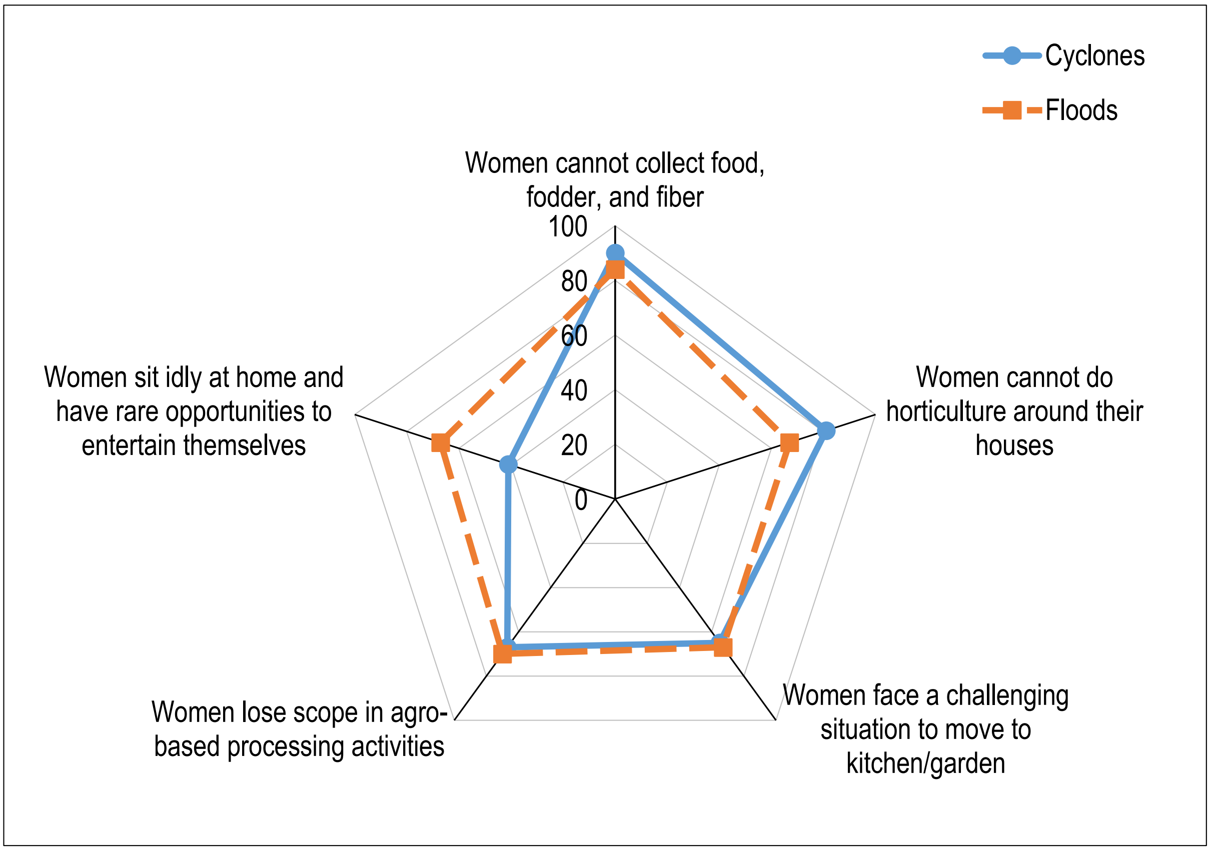
Source: Household Survey, 2019–2020.

6.8.4 Hunkering down during extreme climate events: a possible effect on increased coital frequency

During the household survey, women from both villages reported that extreme climate events had an impact on the economic and regular household activities undertaken by the men and women affected by them. Their everyday activities could be hampered by the frequency, intensity, and/or duration of a flood or cyclone. Figure 6.6 shows that a similar percentage of respondents in both villages faced problems collecting food and fodder, processing agro–based products, and accessing kitchen and vegetable gardens. However, more respondents in the cyclone-hit village than in the flood-hit village could not undertake horticulture, due to salinity in the soil and groundwater. In contrast, more respondents in the flood-hit village spent their time sitting idly at home and had rare opportunities to entertain themselves during the event.

Men and women who cannot move easily frequently hunker down at home or in a place of shelter for prolonged periods during climatic events. Men reported that they tend to spend this time looking after their younger children to protect them from the risk of drowning. They have good reason for this: child mortality due to drowning is higher in the Sunamganj district in which these men from Lamagaon live, than in other districts of Bangladesh (Gruebner et al., 2017).

Figure 6.6 Impacts of extreme climate events on women's household economic activities, in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).



Source: Household Survey, 2019–2020.

During a focus group discussion, a fisherman aged 46 years from the flood-hit village stated:

> *Fishing is the only job I [can] do during the flood season, from June to November. If someone does not want to go fishing, they have to hunker down at home for six months or choose to go to the nearby city of Sylhet, the capital city of Dhaka, or elsewhere to work. However, there remains a concern – who will take care of my children and wife when I am absent, and protect them from the adverse impacts of floods? (Participant 14, FGD, flood-hit village of Lamagaon)*

A 32-year-old farmer from the flood-hit village described his life during the flood season:

> *I hunker down and sit idly at home with my wife and children during the flood season. My wife and I pray to God to save us from that disaster and wait for the water to go down. We cannot visit any place when our surroundings turn into a sea; instead, we*

stay at home and engage in gossip about different topics. I can go to the village market to watch television or spend time with friends doing something else. However, it is challenging to leave behind my family at risk when it is an extreme flood. (Participant 13, FGD, flood-hit village of Lamagaon)

Another farmer aged 45 years living in the cyclone-hit village also addressed the tension between working and protecting his family during an extreme event:

Most of our male dwellers are more likely to migrate to nearby urban areas for certain times of the year to secure their livelihood. We would love to migrate to secure our livelihood and to [make it easier to get the things we need]. However, how would you think about migrating for your livelihood if it meant putting your beloved wife and children at risk of cyclones—who else can best ensure their safety? I think my family is unsafe without me during extreme climatic events such as cyclones and floods. (Participant 4, FGD, cyclone-hit village of Chadnimukha)

The attachment theory of psychology literature contends that couples seek support and physical closeness from their partner and friends, especially during times in which their stress levels are elevated (Zeifman & Hazan, 2008). Thus, studies (Cohan & Cole, 2002; Davis, 2017) have found that being close is expected to increase coital frequency between couples, increasing pregnancies and subsequent births. Findings from the two disaster/fertility-related studies confirm that attachment theory could be seen in practice in the aftermath of Hurricanes Hugo in 1989 in South Carolina (Cohan & Cole, 2002) and Mitch in 1998 in Nicaragua (Davis, 2017). Post-disaster fertility increases have been found to have been influenced by the intense and bonding time couples spent together. Following the 2009 earthquake in L'Aquila, Italy, the number of women who desired a child increased by 22.6 percent. Moreover, the sexual drive, moments of physical closeness, and the frequency of intercourse were reported to have increased by 18.6 percent, 36.2 percent, and 14.4 percent, respectively, after this earthquake (Carta et al., 2012).

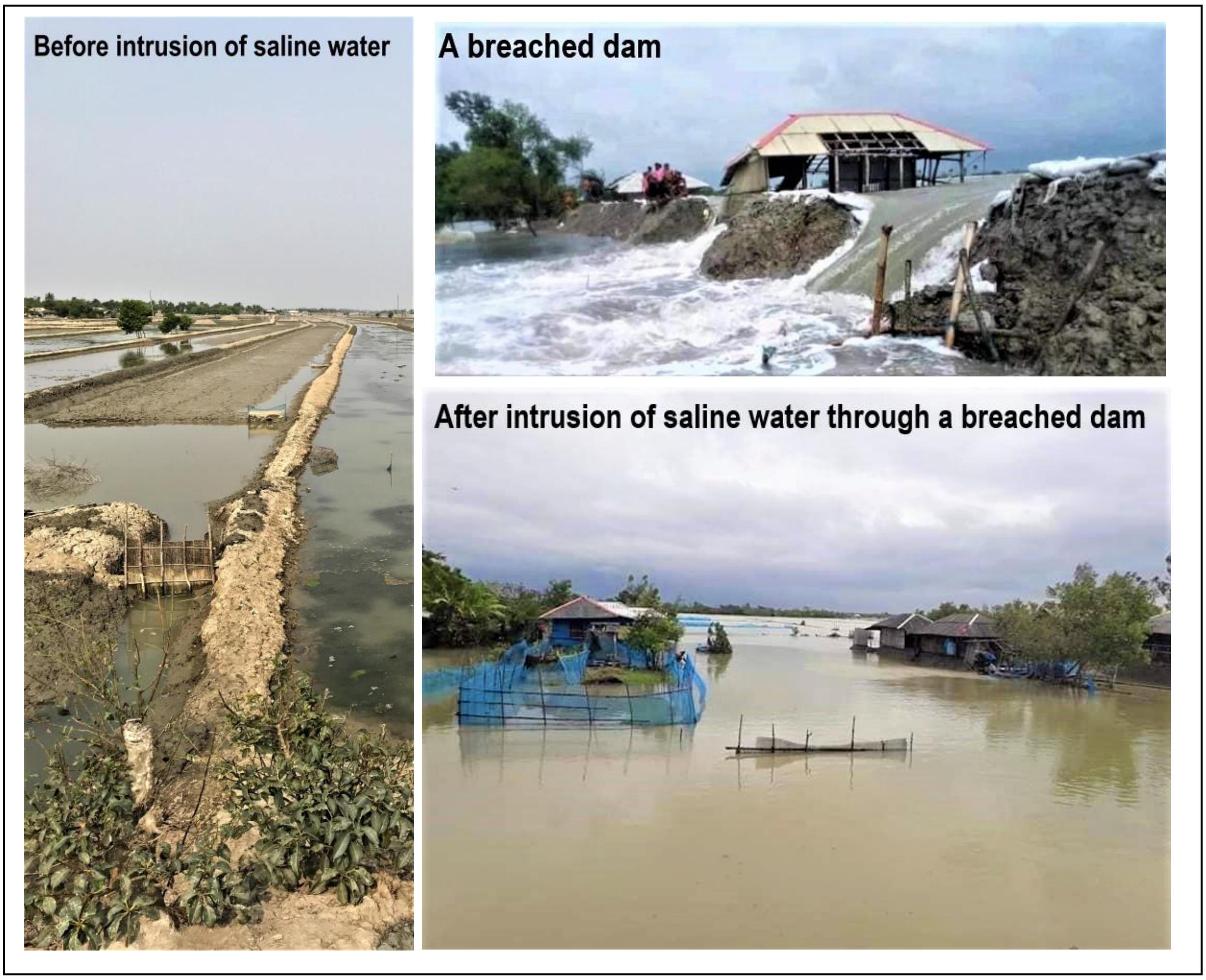
Although neither the men nor the women who participated in this study referred explicitly to it, this same inability of couples in the study villages to continue with their daily activities or engage in regular entertainment or social networking may have also driven increased coital frequency.

6.8.5 Physiological effects of extreme climate events on the fecundity, and fertility of women, and on rates of miscarriage

As has been described in detail above, weather or extreme climate events can have various effects on the fertility and reproductive health of women. Specific physiological effects are related to salinity in household water from tidal surges, food insecurity from damage to agricultural land and crops, the physical effort required to repair damage, and both security and stress driven by the presence and absence of disaster warning systems.

The inundation of communities by salt water has a number of adverse effects above and beyond loss of life, livelihood, and property. Cyclones carry saline capable of harming people's quality of life, health, socioeconomic standing, and livelihood methods from the sea to coastal communities. Plate 6.2 illustrates how a storm-breached dam allows seawater to penetrate the settlement area. During a focus group discussion on this subject, the residents said that the dam had cracked in multiple places and that tidal water was, as a result, entered the region through several large and tiny breaches. They also reported saltwater seepage resulting from Cyclones Sidr in 2007 and Aila in 2009. Agricultural land and freshwater ponds, canals, and rivers were polluted with salt, greatly extending the impact of the storm itself. Although this pollution caused problems that afflicted both men and women, women were disproportionately affected, as, without access to their usual freshwater ponds, they had to rely on the salty water from tube wells for domestic activities such as laundry, dishwashing, and other water-intensive tasks.

Plate 6.2 Intrusion of saline water through a breached dam in the cyclone-hit village of Chadnimukha.



Notes: First image (in left) showing the situation of the village before the intrusion of saline water, was taken by the researcher [Khandaker Jafor Ahmed] during his field visit to Chadnimukha village in 2019-2020; the following two images (in the right) were collected from the Gabura Union Office, showing a breached dam and the change of village landscapes after the intrusion of saline water through a breached dam.
Source: Fieldwork, 2019–2020.

People in cyclone-prone communities get their drinking water from several sources. Water problems typically only exist during the dry season (November–early May), due to low rainfall and river discharge, and rises in the salinity of surface waterways such as streams and canals. Furthermore, ponds frequently dry up during the dry season, leaving coastal communities with little alternative but to use groundwater for drinking and cooking. During the rainy season (May–October), coastal communities frequently collect rainwater at the household or community level, using rainwater collecting facilities of the type shown in Plate 6.3.

Plate 6.3 Rainwater harvesting in cyclone–hit villages of Bangladesh.

Notes: The first image (on the left) showing the household level rainwater storage tank was taken by the researcher [Khandaker Jafor Ahmed] during his fieldwork in cyclone-affected Chadnimukha village in 2019-2020; the second photo (on the right) was collected from the internet showing that a group of women was collecting water for drinking from a community level rainwater collection facility in another coastal village in Bangladesh. The link for the second image is:
https://www.gcca.eu/sites/default/files/inlineimages/Rainwater%20harvesting_Bangladesh.jpg
Source: Fieldwork, 2019–2020.

Families in cyclone-prone communities have been found to be unable to obtain adequate drinking water through winter rainwater harvesting, which has forced them to rely on groundwater and ponds as sources of drinking water during these months. According to a survey by Rasheed et al. (2014), women in coastal Bangladesh consumed more salt than men, through their drinking water. Drinking salt water increases total sodium intake, which can in turn increase the risk among pregnant women of pre-eclampsia and high blood pressure that can increase their risk of miscarriage (Khan et al., 2014; Nahian et al., 2018; Shammi et al., 2019).

During a key-informant interview, a government official in the Shyamnagar sub-district identified the salinity problem as one of the causes of increased rates of infertility in the cyclone-prone Satkhira district. He said:

Because of the negative impacts of salinity, the rate of infertility is increasing in this region. We are aware that many government interventions exist to regulate the birth rate, such as the policy of having no more than two children. Our district, though, is in a different predicament. We are one of Bangladesh's lowest fertility zones on record. I recently attended a session hosted by a research institute in our sub-district. According to their findings, the rate of infertility has continued to rise in this region. They noted the detrimental impacts of climate change, increasing cyclone frequency and severity, storm surges, and salinity in surface and groundwater. (Upazila Nirbahi Officer, KII, cyclone-affected sub-district of Shyamnagar, 2019)

Food insecurity arising from extreme climate events also has physiological effects on the fertility of women. As discussed in Chapter 5, most households in the study areas reported experiencing food insecurity for at least four months a year, on average, regardless of climate events, and that severe weather effects could cause further problems with food production. The pregnancies of women who are malnourished can result in miscarriage. Drought and associated famine have been found to have decreased the conception probabilities of women in Bangladesh (Razzaque, 1988), China (Ashton et al., 1984; Coale, 1981), Ethiopia (Linstrom & Berhanu, 1999), and Finland (Fellman & Eriksson, 2001). Increased nutritional imbalance due to food insecurity may also increase the risk of infant mortality and, in response to that mortality, increase the fertility of women.

Therefore, it can be said that extreme climate events are likely to affect food production and lead to food security compromises. Fertility rates have also been found by Chen et al. (2021) to be directly and indirectly positively affected by climate parameters, particularly maximum temperature that affect through crop production in Bangladesh. These researchers found that maximum temperature was conducive to major crop production (e.g., rice) in the country. This crop production directly increased fertility rates by improving the access of pregnant women to food, and indirectly decreased fertility rates via its negative effects on infant mortality rates. In other words, infant mortality rates decreased with increased crop production and, therefore, reduced fertility rates.

Food security and associated dietary habits are likely to positively affect the reproductive health of women. Despite the fact that household survey respondents from the flood-hit village stated that they struggled to find food for at least four months a year, it has also been found that, at times when food comes more easily, people living in flood-affected areas have access to adequate freshwater fish, whole grains, vegetables, and safe drinking water. Floods aggregate and distribute rich and nutritious soils in low-lying areas, making them well suited to agricultural development and fruitful. According to Panth et al. (2018), men and women who have a diet rich in whole grains, vegetables, fish, and high quantities of unsaturated fats are more fertile. During a key-informant interview, a government official in the Tahirpur sub-district emphasised that the health of the populations living in flood-hit regions is related to their dietary habits as follows:

> *Several kinds of freshwater fish are available in this wetland region during the flood season. Fish is extraordinarily cheap, even affordable, for impoverished households if they do not fish, and [fish is] the most common food in the everyday diet of people who live in flood-hit villages. After the seasonal flood, the low–lying floodplain turns into fertile fields, farmers yield different kinds of crops and winter vegetables. (Project Implementation Officer, KII, flood-affected sub-district of Tahirpur, 2019)*

Given all the above, it can be said that extreme climate events are likely to affect food production and lead to both food security compromises and benefits which can directly or indirectly affect the reproduction of women.

Even the act of cleaning up after an extreme climate event can affect fertility. Participants during focus group discussions and in-depth interviews reported that males and females are more likely to have to spend more time repairing their damaged houses and properties following a cyclone.

During a focus group discussion, a farmer aged 45 years living in the cyclone-hit village described the act of cleaning up after a cyclone:

> *After a cyclone, we spent many days and nights cleaning areas, trimming off broken branches of trees, repairing damaged homes and collapsed embankments, relocating properties, and collecting emergency aid. This time, women and children help us a lot*

to deal with the act of cleaning up, households with more people are greatly benefitted at this time. (Participant 4, FGD, cyclone-hit village of Chadnimukha)

In contrast, the impact of flood is likely to be minimal in the settlement area and people spend less time repairing the damage incurred. More laborious efforts are needed before, during, and after a cyclone than is the case for a flood. Plate 6.4 illustrates the work involved in the repair of damaged embankments in the cyclone-hit village; doing this work, males spend a great deal of time outside the home, and they get fatigued, leading to less sexual activity. It has been reported in a study that extreme fatigue was significantly associated with participants reporting the least amount of sexual activity (Tan, 2021).

Plate 6.4 Males and females were engaged in repairing houses and a collapsed embankment in the cyclone-affected Gabura union.

Notes: **A**. males and females were engaged in repairing their damaged houses and properties after a cyclone that hit a village in Gabura union; **B**. people gathered for fear that the dam might collapse completely and they were ready to protect the dam from further damage; **C** & **D**. Males were seriously engaged in physically demanding labour activities to repair the dam after it was collapsed.
Source: Fieldwork, 2019–2020. [All photos were collected from the Gabura Union Office.]

The amount of warning people receives before an extreme climate event can also affect fertility. In their study of the relationship between fertility rates and catastrophic events, Evans et al. (2010) investigated four storm warnings given on the east coast of the United States: *tropical storm watch, tropical storm warning, hurricane watch*, and *hurricane warning*. Their observations indicated that fertility decreased as the severity of the warning for the storm or hurricane rose: an additional 24 hours of tropical storm warnings, for example, resulted in a 2.1 percent *increase* in births 9 months later, and an additional 24 hours of hurricane warnings resulted in a 2.2 percent *decline* in births. These researchers also observed the storm warnings had the most reproductive influence on couples who already had at least one child. The long-term effect of hurricane warnings on fertility was negative, lowering it by less than 1 percent over three and four years (Evans et al., 2010).

In Bangladesh, coastal areas experience storm warnings regularly; in contrast, flood areas seldom receive warnings of floods. The Bangladesh Meteorological Department (BMD) issues several types of storm signals. Depending on the severity of the storm, signals are issued at or before particular times. Table 6.14 presents the maritime cyclone warning systems in Bangladesh.

Table 6.12 Cyclone warning systems for maritime in Bangladesh.

Stage	Maritime signal	Wind speed (kph)	Issued at or before (hours)	Updates every (minute)
Distant alert	*Cautionary* signal no. **I**	51–61	As needed	As needed
	Warning signal no. **II**	62–88	As needed	As needed
Cyclone alert	*Local cautionary* signal no. **III**	40–50	36	As needed
Cyclone warning	*Local warning* signal no. **IV**	51–61	24	As needed
Cyclone danger	*Danger* signal no. **VI**	62–88	18	30
Cyclone great danger	*Great danger* signal no. **VIII**	89–117	10	15
	Great danger signal no. **IX**	118–170	10	15
	Great danger signal no. **X**	>170	10	15

Source: Compiled from Habib et al. (2012) and Roy et al. (2015).

Evans et al. (2010) have shown that when a weather service issues a warning, fertility can be affected by the way(s) individuals or households respond. People are likely to take preventative measures such as evacuating in accordance with the intensity of the signal. During a low-level cyclone alert, people are less likely to evacuate to a cyclone shelter and instead spend more time hunkering down with family, which might lead to higher sexual activity due to the closeness, the need for reassurance, or even the lack of leisure alternatives. During a high–level warning, family members are more likely to be busy undertaking other preventive behaviours, such as arranging household and property and preparing to evacuate to a safe public building or cyclone shelter. There could be less sexual activity as a result.

During an in-depth interview, a 30-year-old woman living in the cyclone-hit village shared her experiences of cyclone warnings and the preparation they inspire as follows:

> *There are two seasons in a year when we receive cyclone warnings. One is between March and May, and another is between October and November…When we receive the cyclone signals numbered between 8 and 10, we think that something destructive will happen. We get panicked then. We then get busy evacuating to safe places such as cyclone shelters or other public buildings. If the signals are below 8, we prefer to stay at home and keep our eyes open for updates of the storms. (Participant 4, IDI, cyclone-hit village of Chadnimukha)*

While this respondent did not mention fertility in the context of these preparations, it is clear that, in her experience in Bangladesh, particular levels of warning prompt specific responses that would exclude or include the prospect of intimacy that would influence fertility.

People living in the cyclone-hit village receive several cyclone warnings every year. In their study of the mental health of people affected by cyclones, Hasan et al. (2020) found that these warnings are likely to create anxiety and panic among the coastal people in Bangladesh, particularly among females. Anxiety and stress among women have been found to be associated with poor reproductive health that can affect fecundity (Palomba et al., 2018). Examining mental health complexities more broadly went beyond the scope of this, however, it would be helpful if future research explored the relationships between extreme climate events, mental health complexities, and effects on reproductive health and fertility.

6.8.6 Extreme climate events, seasonality of migration, marriage, birth, and fertility

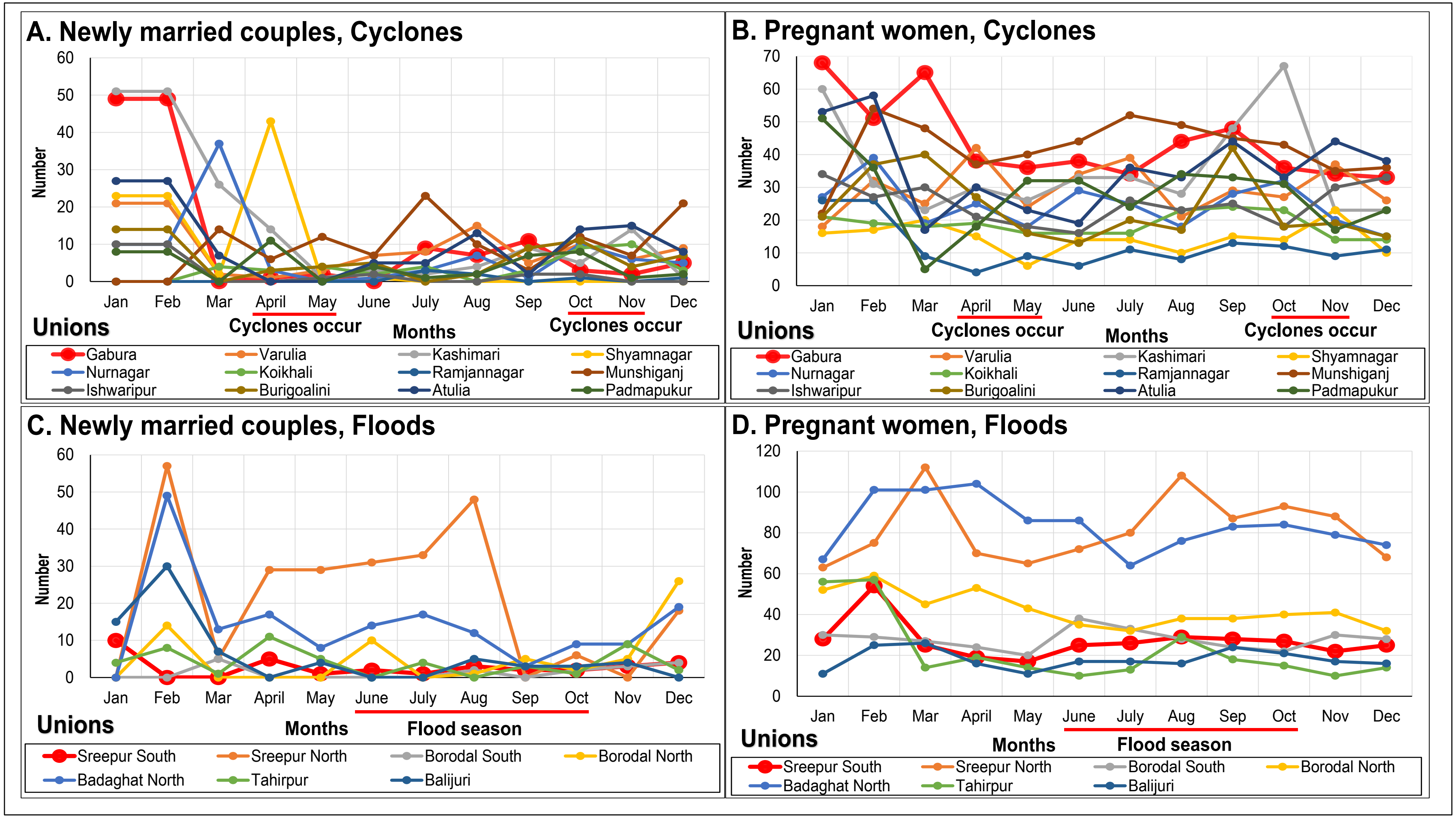
In the 1980s, research was conducted in Bangladesh that identified seasonal peaks of birth and conceptions (Becker, 1981; Becker et al., 1986). In their study, Becker et al. (1986) explained that the frequency of intercourse was a significant factor leading to the seasonal variation of conceptions and births in Bangladesh.

This study explored a number of seasonal aspects associated with extreme climate events and their influence on fertility. One such aspect is male migration. Qualitative findings from focus group discussions showed that male members in the cyclone-hit village migrate to nearby urban areas for a month or several months of rice harvesting. The cropping pattern of Chadnimukha is entirely different from other parts of the country, since this coastal region is so vulnerable to salinity in soil and groundwater. The men from this village migrate to other areas to harvest local *Boro* rice from April to May and *Aus* rice between July and August. Those who do not migrate typically stay in the village to catch shrimp and crabs. Men in the flood-hit village, on the other hand, were less likely to migrate for livelihood; they are able to gain work harvesting rice in their own region. This finding reflects that of Gray and Mueller (2012), who found floods to be minimally related to population mobility, and that it is mainly the poor who migrate.

As addressed in Chapters 5 and 6, the findings of this research have shown that households living in the cyclone-hit village were more vulnerable than those in the flood-hit village (Chapter 5). Moreover, households were more likely to be *highly* vulnerable to past climatic events in the cyclone-hit village than those in the flood-hit village (Section 6.3). It can be argued that, because cyclones are associated with prolonged adverse effects on livelihoods and reductions in the adaptive capacity of households, the experience of these extreme climate events affect migration decisions, and this migration can influence fertility decisions.

Monthly data on the number of newly married couples and pregnant women in 2019, collected by the Upazila Family Planning Office in both study area sub-districts, showed primary peaks of marriage and conception in late winter (January and February) and the beginning of spring (March) in all *unions* (Figure 6.7, A, B, C, D). However, the peak of marriage in both sub-districts started rising from December. The observed peak of marriage and conception in dry seasons can be linked to the adverse impacts of floods and cyclones. In the cyclone-hit village,

Figure 6.7 Numbers of newly married couples and pregnant women in cyclone-affected unions of Shyamnagar (*including Gabura*) and flood-affected unions of Tahirpur (*including Sreepur South*) sub-districts in 2019, by month.



Data source: Unpublished data collected from the Upazila Family Planning Office of Shyamnagar and Tahirpur, 2019–2020.

the cyclone season is April to May and October to November; in the flood-hit village, floodwater levels can remain high from June to November. These 2019 findings are concordant with Becker's (1981) aforementioned research, which showed a peak of birth in late October for younger women with low parities, and in January for older women with higher parities. Therefore, the peaks in conceptions occur in the late winter and early spring months (Becker, 1981; Becker et al., 1986). The combination of the above findings indicates a strong link between extreme climate events and fertility.

The seasonality of marriage and birth in the study areas can also be affected by the impact of extreme climate events on livelihood activities. During focus group discussions, participants reported that males in the flood-hit village usually spend the majority of their time at home through the stages of rice production: land preparing, seed planting, maintaining of the field, and harvesting. In August (the peak of flood season), an increase in conception in the Sreepur North union is often found (Figure 6.7) at the time when men are typically spending their time idly at home without any entertainment and with restricted mobility. During a key-informant interview, the Family Welfare Assistant from the flood-hit village reported a notable high in the number of births at the end of flood season in October and November, indicating the effects of the high number of couples who had married at the beginning of that year. Furthermore, she reported another significant increase in the number of births in April and May, indicating that coital frequency among married couples was likely associated with the flood season that had peaked nine months before. In contrast, in the cyclone-affected Gabura union, there was a minor rise in conception between July and September (Figure 6.7). This increasing conception in July and September can be attributed to the season in which men are more likely to spend most of their time in the village and rely on fishing for income instead of migrating elsewhere. Another possible explanation for this increase in conception can be the elevated coital frequency of couples celebrating the return home of migrating husbands after a separation of a couple of months. Excerpts of key-informant interviews with Family Welfare Assistants indicated that this might be the case. Representatives from the local family planning officials of both villages said that:

> *Tahirpur district is well known for its maximum rice production in Bangladesh. A very large number of labourers, including migrant labour, are needed there during the rice harvesting seasons in the dry months [April and May]. However, the farmers in our*

district and other potential labourers do not migrate elsewhere during the rice-growing season, starting from the rice plantation in early winter, in December, to rice harvesting in April. Therefore, men usually spend most of their time at home, particularly in the evening, during the months between December and April…There are more births reported in October and November, and some in April and May (Family Welfare Assistant, flood-affected Sreepur South Union, 2019)

Many males of our village migrate for more or less than three months after the rainy or flood season, between October and December. However, the length of that migration depends on their livelihood options and need. Many men stay at home fishing between April and August, and others migrate for rice harvesting… However, most of the births in the Gabura union happen between November and March. (Family Welfare Assistant, cyclone-affected Gabura Union, 2019)

The combination of the above findings indicates a strong link between extreme climate events and the seasonality of migration and marriage that influence fertility. While each extreme climate events are unique and occur in different times, they can make variations in the season of migration, marriage, and fertility.

6.9 Conclusion

Overall, this research found that the women of flood-hit Lamagaon were more likely to have a greater number of children than women of cyclone-hit Chadnimukha, where there was a reluctance to have more children. In this study, the assumption was held that differences in the fertility of women exposed to cyclones and floods could be associated with the impacts of such events on the determinants that could influence their fertility. Overall findings indicate that respondents had fewer children if they had experienced more cyclones and more children if they had experienced more floods.

Results from this study confirm that the vulnerability of households to past extreme climate events influences the fertility of women. Cyclones had a significant impact on fertility – those households in the cyclone-hit village that were deemed *highly* vulnerable had limited their number of children. Selected determinants related to vulnerability were significantly associated with the lower fertility in the cyclone-hit village: increasing land size, years of schooling of the heads of households, and assistance received from social networks during crises. In contrast, farmers living in the flood-hit village had more children.

Extreme climate events are unique and highly impactful, and can influence a number of demographic determinants that can affect fertility, and considering this influence can add significant value to the established determinants of fertility. It was found that floods affect determinants that motivated women to have more children. Conversely, cyclones affect determinants that encouraged women to limit their childbirth. Notably, determinants that were shown to increase births include but are not limited to unplanned pregnancies stemming from a lack of access to health facilities and/or the unavailability of contraceptives, the risk of child mortality, and preference for sons. On the other hand, determinants that decreased births are associated with the timing of first birth, physiological effects, household vulnerability, and seasonal migration. Some of these critical determinants are likely to affect the intentions of women to have more children in future.

Chapter 7 Fertility Intentions and the Effects of Extreme Climate Events

7.1 Introduction

There is a significant ethical and policy imperative to understand the links between climate and fertility in least developed countries like Bangladesh (Grace, 2017). This chapter addresses three research questions to identify how extreme climate events have affected the fertility intentions of women in Bangladesh's cyclone- and flood-affected areas:

1. How do the experiences and perceptions of women of extreme climate events influence their fertility intentions?
2. How does the vulnerability of the household to extreme climate events influence the intentions of women to have more children?
3. Are determinants associated with extreme climate events better able to explain the fertility intentions of women above and beyond established determinants of fertility?

Some determinants of fertility that were established in the previous chapter are also used in this chapter to investigate the fertility intentions of women.

This chapter describes in detail how the quantitative and qualitative data was used to inform a number of statistical models that were developed to answer each of the above questions. The final section of this chapter seeks to understand by triangulating quantitative and qualitative findings, how perceived behavioural control (i.e., the intention to have another child in the next 3 years from the point of the survey in this study), a component of the theory of planned behaviour (TPB) that shapes the intentions of an individual, is influenced by different determinants, including but not limited to the effects of extreme climate events. Finally, this chapter concludes with a summary of key findings that highlights the contrasts between the two study areas.

7.2 Fertility intentions of women in the study areas

In this study, fertility intentions are conceptualised as the desire or intent to have another child, the intent to have a certain number of children, and the intended spacing between births. The household survey questionnaire asked married women who had at least one child a direct question: “Do you intend to have another child during the next three years?” This question included four responses: “definitely yes”, “probably yes”, “probably not”, and “definitely not”. Because of the lower number of distribution in ‘probably yes’ and ‘probably no’ categories, these responses were coded into two groups: 1 (yes) and 0 (no). The questionnaire then asked women to indicate how many children they intended to have before menopause. Those women who indicated their intention to have another child during the next three years were asked an additional question: “How many years after your upcoming [if they were pregnant during the survey] or recent birth or from the point of this survey would you like to have another child?” This question included three responses: “within a year” / “very soon”, “two years” / “soon”, and “three or more years” / “later”.

Table 7.1 shows that more respondents living in the flood-hit village intended to have another child (48.9%) than those in the cyclone-hit village (38%). It should be noted that the group of respondents representing the cyclone-affected village was composed of a greater number of younger women (aged below 25 years) than was the case for the respondents representing the flood-affected village. It was found that respondents in the flood-hit village desired to have more than three children, while respondents in the village hit by cyclones desired to have more than two. Moreover, a similar number of respondents in both study areas, particularly those who were younger and had fewer children (see *Table C11*, *Appendix C*), intended to have another child within a year. In contrast, older women (aged over 35 years) with a higher number of children were not as likely to plan to have additional children. It was found that a greater number of respondents in the flood-hit village than in the cyclone-hit village (40.7% and 31.1%, respectively) intended to have another child after three or more years. Younger respondents with more children in the flood-affected village were more likely to delay their next birth (see *Table C11*, *Appendix C*). Not surprisingly, given what has been discussed in this thesis, the fertility intentions of the women in this study were found to differ in accordance with their demographic, economic, social, and extreme climate events-related determinants.

Table 7.1 Fertility intentions of women in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Determinants	*Cyclones*	*Floods*
Fertility intentions		
Intention to have another child (%)		
No	62.0	51.1
Yes	38.0	48.9
Mean (SD) of desired number of children	2.18 (.624)	3.04 (1.060)
Desired spacing to have another child* (%)		
Very soon	37.8	38.9
Soon	31.1	20.4
Later	31.1	40.7

Source: Household Survey, 2019–2020.

7.3 Experiences and perceptions of extreme climate events and fertility intentions

This section analyses the findings to determine whether and to what extent experiences and perceptions of extreme climate events influence a woman's intention to have another child. Key findings presented in Chapter 6, Figure 6.1, showed that most women had extensive experiences with and realistic perceptions of extreme climate events. Similarly, the qualitative findings of in-depth interviews with women also indicated that, if they had experienced extreme climate events, they perceived that there would be more such events in the future. This is reflected in the following description given by a 28-year-old woman in the flood-hit village:

> *I saw a destructive flood in 2004 when the water level was very high. Every household had to build a* matcha *[an elevated surface made from bamboo or wood] during that flood in 2004. Afterwards, there were two or three floods that had limited impacts on our village dwellers. However, this year's flood (2019) was remarkable—it caused structural damage to many houses and the loss of valuable assets and properties. Due to the high water level, people were in deplorable living conditions and could not leave their homes for more than a month. (Participant 5, IDI, flood-hit village of Lamagaon)*

Respondents in the cyclone-hit village had a slightly higher mean score on statements relating to their experiences and perceptions than was the case in the flood-hit village (as illustrated in Chapter 6, Figure 6.1). The average score for each statement was first calculated by adding responses on a five-point Likert scale (1-5) and dividing by the number of respondents. Once an average score of the four statements of 'experience' and 'perception' is obtained, they are added together and divided by four. Mean scores of perceptions and experiences were aggregated into three groups: “low” if scores are between 1 and 2.50, “moderate” if between 2.51 and 3.99, and “high” if between 4 and 5 (Table 7.2). They were categorised in this way because categorical determinants allow for the estimation of the probability of an outcome in comparison with a reference group. Binary probit regression was used to explore the relationship between experiences and perceptions of extreme climate events with fertility intentions, where “low” perceptions and experiences was considered a reference group. As was detailed in the previous chapter, Table 7.2 confirms, using a different categorical approach, that women in the cyclone-hit village had more realistic perceptions and more extensive experience of extreme climate events.

Table 7.2 Level of perceptions and experiences about extreme climate events in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Variable	*Cyclones*	*Floods*
Perceptions (%)		
Low	10.2	13.9
Moderate	23.0	42.0
High	66.8	44.1
Experiences (%)		
Low	12.1	23.8
Moderate	14.1	28.6
High	73.8	47.6

Source: Household Survey, 2019–2020.

Three binary probit regression models were used to reveal the effects of these experiences and perceptions on the fertility intentions of the respondents. The first model was used to identify the effects of the *experiences* of extreme climate events; the second model was used to analyse the effects of *perceptions*, and the third model factors in both *experiences and perceptions* to see their effects in a complete model. The models considered the age and education of the mother as potential confounders affecting fertility intentions. It was found that the group of respondents from the cyclone-affected area included a larger percentage of younger women, and that the number of older respondents (aged above 35 years) was quite similar in both villages. Moreover, respondents living in the cyclone-hit village had completed higher levels of education, particularly secondary and higher secondary schooling. These variations in the age and education can help to explain variations in fertility intentions.

The results of the binary probit models are presented in Table 7.3. The model fit is measured according to AIC and BIC values, with smaller values indicating a better fit. For example, the experience model is most fit to explain variations in fertility intentions in the village hit by cyclones, as the AIC and BIC values (59.18 and 89.15, respectively) are lowest for *Model 1 (experiences)* for this village. As expected, all models show that the age and education of the mother had a significant negative effect on fertility intentions. In other words, older respondents and those who had attained higher education were less likely to have another child. Comparing the results of *Model 1 (experiences)* for the two villages shows that the level of experience of cyclones negatively affected the intention to have another child: participants were less likely to have another child if they had a "high" or "moderate" experience of cyclones. Experiencing a greater number of extreme climate events is likely to adversely affect the socio-economic conditions of households, make these households more vulnerable, and drive the intention to have fewer children, in order to cope.

Model 2 (perceptions) reveals that their perceptions of extreme climate events had a significant negative effect on the fertility intentions of respondents in the cyclone-hit village. Considering experiences and perceptions together in a single probit model, as in *Model 3 (experiences & perceptions)* improves the model. Both perceptions and experience of cyclones became significant in this model. Experience with and future risk of extreme climate events can be a critical channel through which such events can affect fertility, because an increase in concerns about climate or environmental issues is associated with a suppression of fertility intentions (Arnocky et al., 2012; De Rose & Testa, 2015).

It was found that experience or perceptions of floods did not significantly affect the fertility intentions of women in Lamagaon. This is likely to be due to the fact that floods in Bangladesh have evolved very uniquely, affecting most areas of the country over a long period, and residents have developed their own unique coping and adaptation strategies in response to flood impacts.

The binary probit model results presented in Table 7.3 for the respondents from the flood-hit village show that their experiences and perceptions of floods had not had a significant effect on their fertility intentions.

Table 7.3 Binary probit model results: parameter estimates for women who intend to have another child in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Variables	***Cyclones***			***Floods***		
	Model 1 (Experiences)	**Model 2 (Perceptions)**	**Model 3 (Experiences & perceptions)**	**Model 1 (Experiences)**	**Model 2 (Perceptions)**	**Model 3 (Experiences & perceptions)**
	Coef.	**Coef.**	**Coef.**	**Coef.**	**Coef.**	**Coef.**
Age						
18–24 (ref)						
25–34	–1.23***	–1.30***	–1.12***	–1.48***	–1.54***	–1.55***
35–49	–2.68***	–2.54***	–2.72***	–3.04***	–3.18***	–3.19***
Education						
No schooling (ref)	–.77***	–.61***	–.65**	–.21	–.20	–.19
Primary school	–..90***	–.85***	–.98***	.17	.23	.24
Secondary school	–7.73	–7.87	–7.78	–1.36***	–1.60***	–1.58***
Higher secondary school						
Experience						
Low (ref)						
Moderate	–2.53***		–2.95***	–.20		–.05
High	–2.09***		–3.11***	–.35		–.04
Perceptions						
Low (ref)						
Moderate		–.482	.010		.48	.50
High		–.187	–1.20**		–.29	–.26
Chi–square statistics	206.75***	168.87***	221.92***	121.42***	131.76***	131.79***
Log–likelihood	–21.59	–31.54	–33.53	–33.20	–27.88	–44.86
AIC	59.18	79.08	87.79	82.41	71.76	109.73
BIC	89.15	109.05	124.52	109.95	99.30	144.15

Notes: Reference category: *do not intend to have another child*; *** p < .01, ** p < .05, * p < .10.

Source: Household Survey, 2019–2020.

7.4 Nexus between households' vulnerability, impact of extreme climate events, and fertility intentions: a modelling approach

A multi-step regression procedure was used to address unobserved determinants such as vulnerability dimensions that influence, directly and indirectly, both the impact extreme events can have on households and the fertility intentions of women. For the purposes of carrying out the multi-step regression procedure, it was necessary to create and distinguish between dependent and independent determinants, to define these determinants, and to indicate their suitability for use in the *impact model*, the *intention model*, or both. Table 7.4, below, presents a detailed outline of these determinants.

The household survey questionnaire asked respondents about the impact of extreme climate events on their households in relation to agriculture and aquaculture, livelihood, housing, food security, and health during the cyclone or the flood experienced in their respective villages in 2019. According to the key-informant interviews with stakeholders and focus group discussions with male village leaders, knowledgeable people, and villagers with different occupations, these five dimensions of well-being were the most affected by extreme climate events in 2019.

To understand the impact of extreme climate events on *agriculture and aquaculture*, the questionnaire asked: "To what extent did your household suffer the damage or loss of standing crops in the farm or fish/shrimp in the shrimp ponds during the extreme event in 2019?" Answers to the question were coded as 0 (no impact) and 1 (significant impact). To identify the impact on *livelihood*, the questionnaire asked: "To what extent were the natural or non-natural sources of income for your household affected and associated with a loss of employment and a decrease in total income for at least 3 months?" The coding of the answers to the question was similar to those for the previous question. The question to determine the impact on *housing* was: "To what extent did the extreme climate events in 2019 cause partial or complete structural damage to your house which required significant repairs?" Because few households reported complete damage, answers were coded as 1 if they had experienced partial or complete damage and 0 if there was no damage. Assessing the impact of extreme climate events on *food security* involved the question: "Did your household face a shortage of staple

Table 7.4 Definitions of determinants for the model of extreme climate events, household vulnerability, and fertility intention.

Variables	Definition	Binary probit *impact* models (Refer Tables 7.6, 7.7)	Binary probit *intention* model (Refer Table 7.8)
Outcomes			
Impact of extreme climate event(s) in 2019			
Impact on agriculture and aquaculture	1 if household reported significant damage or loss of standing crops in the farm or of fish/shrimp in the *gher* (shrimp ponds); 0 otherwise	√	
Impact on livelihood	1 if natural or non-natural livelihood sources of households were significantly affected and associated with a loss of employment and a decrease in total income for at least 3 months; 0 otherwise	√	
Impact on housing	1 if the disaster caused partial or complete structural destruction to the home which required significant repairs; 0 otherwise	√	
Impact on food security	1 if the household faced a shortage of staple food for at least 3 consecutive months; 0 otherwise	√	
Impact on health	1 if the disaster affected the health of any of household members (e.g., injury, psychological distress, diseases, malnutrition) from during the disaster to 3 months following the disaster, for which they needed to consult a doctor or visit the hospital; 0 otherwise	√	
Fertility intentions	1 if woman wants to have another child in the next 3 years; 0 otherwise		√
Determinants			
Impact of extreme climate event(s) in 2019	See above		√
Family dependency index (FDI)	Population ratio of those aged under 15 and aged above 65 years to those of working-age (over 15 to below 65)	√	√
Livelihood diversification index (LDI)	The inverse of (the number of agricultural livelihood activities + 1) of livelihood activities; e.g. a household that farms, raises animals, and collects natural resources will have an LDI=1/(3+1)=0.25; therefore, a higher LDI score indicates fewer livelihood activities.	√	√
Primary income source(s)	0 = farming, 1 = fishing, 2 = agricultural wage labour, 3 = non-agricultural wage labour	√	√
Agricultural income ratio	The ratio of agricultural income out of the total income of the household	√	√
Health shock	If any of household members reported any of health shocks in the preceding 5 years (2014–2018) prior to 2019 for which they needed to consult a doctor or visit the hospital; 0 = no impact, 1 = infant mortality, 2 = severe diseases, 3 = psychological distress, 4 = severe injury or physical disability	√	√
Assistance sought/received	If household sought or received financial or non-financial assistance from friends, relatives, government, and non-government organisations when extreme climate events occurred or when it faced economic difficulties in the preceding 5 years (2014–2018) prior to 2019; 0 = no assistance received, 1 = assistance from friends or relatives, 2 = assistance from government or NGOs	√	√
Agriculture is major source of staple food	1 if agriculture was the primary source of household's staple food; 0 otherwise	√	√
Number of extreme climate events	Number of extreme climate events which caused economic loss and damage of any amount to household in the preceding 10 years (2009–2018) prior to 2019	√	√

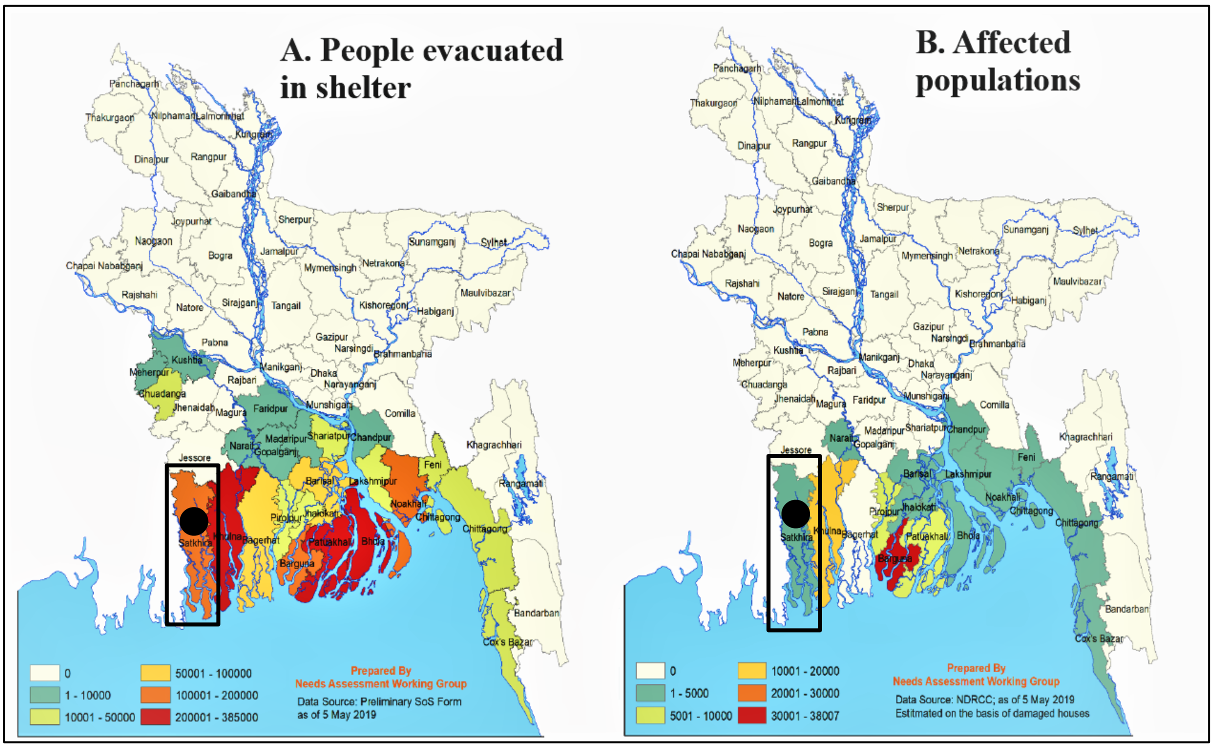
food for at least 3 consecutive months following the extreme climate event(s) in 2019?" Answers to the question were coded as 1 if food shortage had been experienced and 0 otherwise. Finally, the questionnaire asked about the *health* impact: "Did the extreme climate event(s) in 2019 affect the health of any of the members of your household (e.g., injury, psychological distress, diseases, malnutrition) at any time, from during the event to 3 months afterward, for which they needed to consult a doctor or visit the hospital?" Answers to the question were coded as 1 if they had any health impact and 0 otherwise.

As previously noted, this study examined the impacts of extreme climate events on households because they can influence decision-making processes including but not limited to women's fertility intentions. It has also been noted that the household vulnerability dimensions of exposure, sensitivity, and adaptive capacity can further determine the impacts of cyclones or floods, and, in turn, affect decision making. Therefore, for the *impact models* (refer Tables 7.6 and 7.7) developed to identify how dimensions of household vulnerability influence the impact of an extreme climate event in 2019, impact determinants (the determinants associated with the impact of extreme climate events in 2019) are considered dependent determinants. For the *fertility intention model* (refer Table 7.8), impact determinants as well as dimensions of household vulnerability are considered independent determinants; fertility intention is the dependent variable.

Most of the determinants related to vulnerability used as independent determinants for both impact and intention models were discussed in Chapter 6 (refer to Section 6.6.1.1). The increasing frequencies and intensities of cyclones and floods are associated with increased economic and non-economic loss and damage experienced by households, which limit their adaptive capacity. The questionnaire asked respondents to indicate the number of extreme climate events (e.g., cyclones/floods) that had caused them economic loss and damage of any amount in the preceding 10 years (2009–2018). It is worth acknowledging that counting only the frequencies of extreme climate events without a consideration of their intensities may not provide a complete picture of vulnerability. The lack of local-level vulnerability assessment data for each disaster limited the execution of this analysis. However, *frequency* is an established criterion used for hazard mapping, which is frequently undertaken to explore the spatial variations of the impacts of hazards experienced in a region. Moreover, the number of extreme climate events experienced by populations can influence their perceptions and decision-making processes, including regarding fertility intentions.

The vulnerability of households to cyclones and floods was discussed in Chapter 6 (refer to Section 6.6.1.2). In 2019, Cyclone *Fani* struck Chadnimukha village of Gabura union, and a flood inundated Lamagaon village of Sreepur South union. During Cyclone Fani, many people from all coastal and inner coastal districts were evacuated to shelter, as shown in Figure 7.1 A. Between 100,001 and 200,000 people from the Satkhira district were evacuated. The tremendous evacuation efforts in response to Cyclone Fani reduced the incidence of injuries and fatalities, to the extent that in Satkhira, not more than 5,000 people were affected during this cyclone.

Figure 7.1 A. Number of people evacuated to shelter and B. number of people adversely affected during Cyclone Fani (including *Satkhira*) in Bangladesh, 2019.

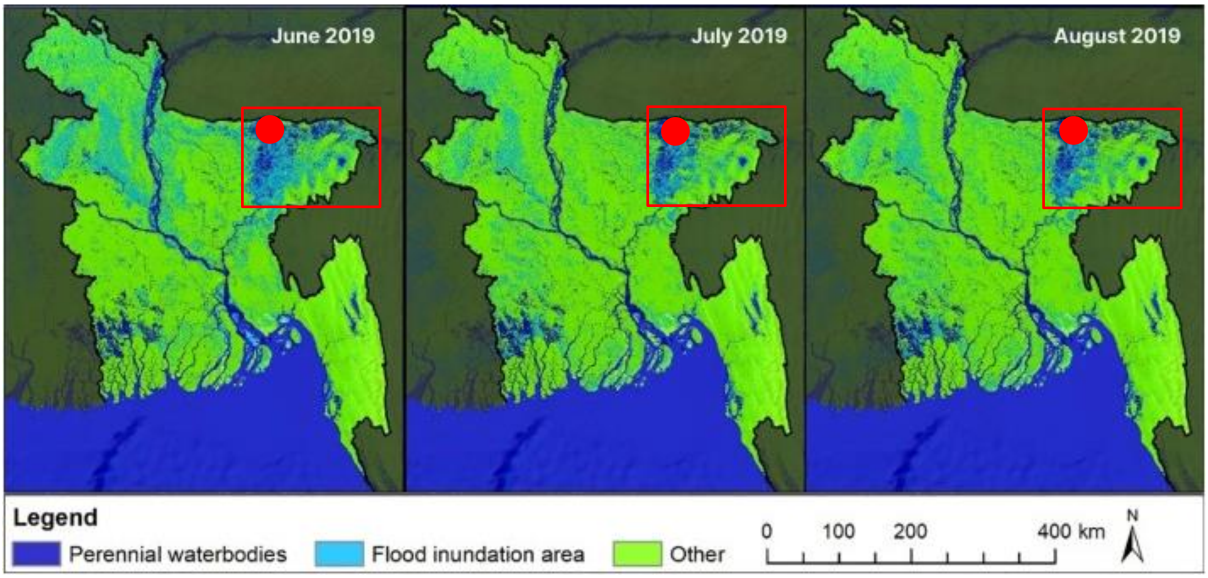


Note: Rectangular in the map indicates the Satkhira district, and the black circle shows the approximate location of Chadnimukha village.
Source: Modified from the Needs Assessment Working Group Bangladesh (2019, p. 23).

According to mapping by Uddin and Matin (2021), as shown in Figure 7.2, between June and August, 2019, during the rainy season, catastrophic floods inundated several areas of the country: 9.50 percent of Bangladesh was underwater in June, 10.56 percent in July, and 5.01

percent in August. Uddin and Matin (2021) further examined the extent of the flood in the divisional areas of Bangladesh and found that floods occur frequently and to the maximum extent in the Sylhet division in the northeast of the country. In 2019, 2.43 percent of the flood inundated area of Bangladesh was from this division in June and 2.69 percent in July.

Figure 7.2 Flood mapping of Bangladesh (including *Sunamganj*), June, July, and August 2019.



Note: Rectangular in the map indicates the Sylhet Division, and the red circle shows the approximate location of Lamagaon village.
Source: Modified from Uddin and Matin (2021, p. 8).

During the household survey, women were asked to indicate the impacts the 2019 cyclone and flood events (respectively) had on agriculture, aquaculture, livelihood, housing, food security, and health. Table 7.5 presents the descriptive statistics based on their responses. It was found that Cyclone Fani adversely affected the well-being of a larger percentage of household in agriculture and aquaculture (43.8%), livelihood (47%), and housing (42.2%) than the 2019 flooding did (33.3%, 42.4%, and 37.2% in the flood-hit village, respectively). These different extreme climate events had affected the food security and health of a similar number of households.

Table 7.5 Impacts of extreme climate events in 2019 on household well-being in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Variables	***Cyclones***	***Floods***
Impact on agriculture and aquaculture		
No	56.2	66.7
Yes	43.8	33.3
Impact on livelihood		
No	53.0	57.6
Yes	47.0	42.4
Impact on housing		
No	57.8	62.8
Yes	42.2	37.2
Impact on food security		
No	44.7	42.4
Yes	55.3	57.6
Impact on health		
No	69.3	71.9
Yes	30.7	28.1

Source: Household Survey, 2019–2020.

Table 7.6 presents the results of the binary probit models of the impacts of extreme climate events of 2019 on the cyclone-hit village of Chadnimukha; Table 7.7 presents the results for the flood-hit village of Lamagaon. Separate models were used to identify the impact of these events on agriculture and aquaculture, livelihood, housing, food security, and health.

7.4.1 Impact on crop production

All but one of the determinants of household vulnerability (the agricultural income ratio) significantly determined the impact of cyclones on agriculture and aquaculture. In contrast, only two determinants significantly determined the impact of floods on agriculture and aquaculture: health shock and LDI. Households in the cyclone-hit village with higher levels of disability, dependency on fishing and agricultural wage labour, support from government and NGOs, dependency on agriculture as the source of staple food, and greater numbers of dependent family members were more likely to experience impacts on agriculture and aquaculture from Cyclone Fani in 2019. Moreover, households in Chadnimukha were less likely to experience the impact of the cyclone on agriculture and aquaculture when they relied on fewer livelihood options. It can be said that, because the economy of the cyclone-affected village is primarily based on wage labour, households can benefit from reduced family size. In contrast, the farming or labour-based subsistence economy of the flood-affected village means that having a large family is more beneficial for income generation.

Table 7.6 Binary probit model results: parameter estimates of the impacts of the 2019 Cyclone Fani on households in Chadnimukha (N=313).

Determinants	Coefficient				
	Agriculture & aquaculture	**Livelihood**	**Housing**	**Food security**	**Health**
Primary income sources					
(ref=farming)	.563*	–.244	.166	1.384***	–.250
Fishing	.582**	–.343	.104	1.498***	–.136
Agricultural wage labour	.150	–.289	.380	1.015***	–.044
Non-agricultural wage labour					
Health shock (ref=no impact)					
Infant mortality	.374	–.332	.121	–.217	.352
Severe diseases	–.048	.159	.582***	.244	1.169***
Psychological distress	.213	.036	.942***	.498*	.751**
Severe injury or physical disability	.562**	.747***	1.009***	–.184	.227
Assistance received (ref=no assistance)					
From friends or relatives	.008	–.372*	–.036	.002	–.276
From government or NGOs	.525**	–.280	.233	.120	.019
Agriculture is the major source of staple food (ref = no)					
Yes	1.194***	.395**	.536***	1.204***	–.049
Family dependency index (FDI)	.344***	.073	.099	.923***	1.197***
Livelihood diversification index (LDI)	–4.088***	–5.596***	–3.596***	–1.616**	.516
Agricultural income ratio	.361	–.463	.384	.932**	–1.163***
Number of extreme events	–.135*	.009	.044	.080	–.149*
Constant	–.140	2.188***	–.302	–2.518***	–.974*
Chi–square statistics	116.360***	103.995***	75.168***	115.310***	141.881***
Log likelihood	–156.339	–162.301	–173.440	–155.478	–120.620
AIC	342.678	354.602	376.881	340.956	271.239
BIC	398.871	410.795	433.074	397.149	327.432

Note: *** $p < .01$, ** $p < .05$, * $p < .10$.
Source: Household Survey, 2019–2020.

Table 7.7 Binary probit model results: parameter estimates of the impacts of the 2019 flood on households in Lamagaon (N=231).

Determinants	Coefficient				
	Agriculture & aquaculture	Livelihood	Housing	Food security	Health
Primary income sources					
(ref=farming)	.021	.523***	.307	.455**	–.412*
Fishing	–.056	–.346	.361	.796***	.268
Agricultural wage labour	.773	.005	–.256	.192	–.574
Non-agricultural wage labour					
Health shock (ref=no impact)					
Infant mortality	.480	–.359	–.575*	–.610**	–.498
Severe diseases	–.738**	.423	.506*	.002	.660**
Psychological distress	–.212	.454*	.511*	.339	.037
Severe injury or physical disability	–.310	.253	.129	.019	–.369
Assistance received (ref=no					
assistance)	.037	.441*	.111	.259	–.042
From friends or relatives	–.108	.187	.349	.753***	–.101
From government or NGOs					
Agriculture is the major source of staple food (ref = no)					
Yes	.256	–.045	–.533***	.068	–.041
Family dependency index (FDI)	–.010	–.008	–.179	.122	.166
Livelihood diversification index (LDI)	1.612*	2.271***	1.152	1.458*	–.965
Agricultural income ratio	.148	.838	.506	.787	.502
Number of extreme events	–.025	–.078	–.049	–.021	.121*
Constant	–.107	–1.723***	–.869*	–1.403***	–.826*
Chi–square statistics	32.023***	37.278***	43.238***	40.631***	34.976***
Log likelihood	–131.023	–138.816	–130.879	–137.140	–119.785
AIC	292.047	307.632	291.758	304.280	269.571
BIC	343.683	359.268	343.395	355.916	321.207

Note: *** $p < .01$, ** $p < .05$, * $p < .10$.
Source: Household Survey, 2019–2020.

7.4.2 Impact on livelihood

Households in Chadnimukha were more likely to report that Cyclone Fani had had an impact on their livelihood if they had disabled members, relied on agriculture as their primary source of staple food, and had fewer livelihood options. Physical injury or disability was likely to prevent someone from participating in the labour force to contribute to the welfare of households. However, receiving assistance from friends or relatives could enhance the adaptive capacity of households, and they were less likely to have witnessed the impacts of Cyclone Fani on livelihood. Households in the cyclone-affected area with “fewer” livelihood options, meaning they depended on wage labour or migration for the majority of their income, were less likely to have witnessed the impacts of Cyclone Fani on livelihood.

Households in the flood-affected area were more likely to have experienced the impact of the 2019 floods on their livelihoods if they counted on fishing for their income, depended on support from friends or relatives in times of need, and had family members who had experienced psychological stress as a result of the event. Moreover, these households who had fewer livelihood options were more likely to have experienced a more significant impact of the 2019 floods on their livelihood, as they typically earned their incomes within the village.

7.4.3 Impact on housing

Households from both areas reported more significant impacts on housing from the 2019 events if they had disabled family members or members with diseases and psychological stress, relied on agriculture as the primary source of staple food, and had fewer livelihood options. The presence of household members with severe diseases, psychological stress, and/or disabilities made it difficult for that household to secure their house from the loss and damage the cyclone/flood caused.

Households in the cyclone- and flood-hit study areas witnessed different impacts on housing, depending on whether agriculture was the major source of staple food. The extent of the impact of Cyclone Fani on households in Chadnimukha dependent on agriculture for staple food tended to be associated with the size of their farm: the larger the farm, the greater the impact. In contrast, households in Lamagaon that had larger farms were less likely to experience the impact of the 2019 floods on their housing. Households in the flood-affected village used the rice straw from their properties to thatch the roofs of their houses and repair any partially damaged parts. Moreover, the rice straw could be used by households to prevent the erosion of areas surrounding their houses and could reduce the impact on housing (see plate 7.1).

Plate 7.1 Use of rice straw to prevent the erosion of settlement area in flood–hit village (*Lamagaon*).

Notes: Rectangular indicates the area where rice straw was used to prevent erosion. This photo was taken by the researcher [Khandaker Jafor Ahmed] during his field visit in Lamagaon, 2019-2020.
Source: Fieldwork, 2019-2020.

7.4.4 Impact on food security

Households from both study villages were more likely to report the adverse impact of the 2019 extreme climate events on food security if their primary income sources were fishing, agricultural wage labour, and if they had fewer livelihood options. Households those dependent on farming were able to store crops such as rice to ensure their food security throughout the year, and these households were less likely to experience seasonal hunger or deprivation of food. Stored crops could also be sold to buy other essential things for households. In the flood-affected village, households typically relied on government and non-government organisations assistance if they were landless or had lost crop yield in a season. After the 2019 floods, these households experienced a more significant impact on their food security.

7.4.5 Impact on health

Households in Chadnimukha were more likely to report impacts on health from Cyclone Fani if they had family members suffering from diseases and psychological stress and a high family dependency index. In contrast, households from the cyclone-affected village who had higher incomes from agriculture, most likely the well-off farmers, were less likely to report impacts on health. In the flood-affected village, the presence of members with severe diseases was also a significant factor associated with the impact of the 2019 floods on health. Moreover, a higher number of floods experienced by households in the past was associated with an increased impact on health.

7.4.6 Impact on fertility intentions

This knowledge of the extent to which respondents experienced adverse impacts of the 2019 cyclone/flood on the five dimensions of household well-being deemed to be the most affected by extreme climate events (see the introduction of Section 7.4) provides a foundation from which to determine whether these adverse impacts influenced the respondents' fertility intentions. Table 7.8 presents the results of binary probit models of fertility intentions for both villages. Three models are presented to identify the extent to which fertility decisions were influenced by the determinants discussed above: *Model 1* reported results associated with vulnerability; *Model 2* reported results associated with impact; and *Model 3* took both vulnerability and impact into account.

The degrees to which the models fit the data were compared using the AIC and the BIC, with, again, smaller values demonstrating a better fit. Among the three models developed for both the cyclone-hit and the flood-hit villages, *Model 2* had the lowest AIC and BIC values, with an AIC of 98.3 and a BIC of 120.8 for Chadnimukha and and AIC of 78.8 and a BIC of 99.5 for Lamagaon. This indicates that the fit of *Model 2* was the best in both cases. *Model 3* had the next-lowest set of results, followed values by *Model 1*, which had significantly higher AIC and BIC values. The particularly low AIC and BIC results for the flood-hit village suggest that it was the impact of the floods that had the greatest impact on the fertility intentions of the respondents from Lamagaon. Though the difference in the *Model 1* AIC and BIC results between the cyclone-hit area and the flood-hit area was minimal, the lower figures for the

Table 7.8 Binary probit model results: parameter estimates for women who intend to have another child in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Determinants	***Cyclones*** **Coefficient**			***Floods*** **Coefficient**		
	Model 1 (Vulnerability)	**Model 2 (Impact)**	**Model 3 (Vulnerability-impact)**	**Model 1 (Vulnerability)**	**Model 2 (Impact)**	**Model 3 (Vulnerability-impact)**
Primary income sources (ref=farming)						
Fishing	–.044		.741	.226		.952*
Agricultural wage labour	–.447		.504	–.224		.234
Non-agricultural wage labour	–.089		.432	.356		.536
Health shock (ref=no impact)						
Infant mortality	1.069***		2.531***	.653*		.120
Severe diseases	–1.207***		–.977	–1.004***		.760
Psychological distress	–.769*		–.123	–.880***		–1.359**
Severe injury or physical disability	–.811**		–1.400**	–.600*		–1.736**
Assistance received (ref=no assistance)	.797***		1.037**	–.247		.136
From friends or relatives	.593**		1.830***	–1.107***		–1.389**
From government or NGOs						
Agriculture is the major source of staple food (ref=no)	–.803**		.119	.972***		2.286***
Yes						
Family dependency index (FDI)	–1.117***		–1.122**	.662***		1.558***
Livelihood diversification index (LDI)	1.872**		–3.977**	.143		3.471
Agricultural income ratio	3.259***		7.262***	1.204*		3.209***
Number of extreme climate events	.010		–.269	.094		.145
Impact on agriculture (ref=no)						
Yes		–.399**	–2.632***		–.990***	.634
Impact on livelihood (ref=no)						
Yes		–.808***	–1.592***		–.105	–1.033**
Impact on housing (ref=no)						
Yes		–.310	–.943**		–1.250***	–2.139***
Impact on food security (ref=no)						
Yes		–.817***	–2.868***		–.671***	–1.851***
Impact on health (ref=no)						
Yes		–1.374***	–1.322**		–.747***	–2.539***
Constant	–2.326***	1.086***	–.655	–1.649***	1.310***	–3.043***
Chi–square statistics	238.948***	145.254***	347.960***	137.450***	116.212***	253.721***
Log–likelihood	–87.714	–43.198	–.33.902	–91.338	–33.433	–33.202
AIC	205.429	98.396	107.803	212.676	78.867	106.404
BIC	261.622	120.873	182.727	264.312	99.521	175.253

Note: *** p < .01, ** p < .05, * p < .10.

Source: Household Survey, 2019–2020.

cyclone-hit village indicate that the vulnerability of the household had a more substantial effect on the fertility intentions of those women than it did on the intentions of the respondents from the flood-hit village.

Looking first at *Model 1*, it becomes clear that, while the determinants of the vulnerability model have a weak effect on fertility intentions, it can still be useful to compare these results from both villages. Working through the determinants reveals the similarities and differences. With respect to *primary income sources*, dependency on agricultural wage labour in 2019 put the strongest amount of downward pressure on fertility intentions of respondents from both villages; the other sources of income reduced and increased the likelihood of additional children in the cyclone-hit and flood-hit villages, respectively. A decrease in the likelihood of having another child was noticeable for households that had experienced *health shocks* in 2019, including severe diseases, psychological distress, and physical injury or disability of members. Those households who had lost children in 2019, however, were more likely to want to have another child. Receiving *assistance* from individuals or organisations had a significant but opposite effect on fertility intentions between areas. Receiving assistance from friends or relatives, the government and NGOs influenced respondents in the cyclone-hit area to plan to have another child and made respondents in the flood-hit area less likely to intend to have another child.

Dependency on *agriculture* to provide staple food influenced respondents in the flood-hit area to have another child, and had the opposite influence in the cyclone-hit area. Children with physical strength can provide households in the flood-hit village with farm labour and help increase food security. In contrast, since the households in the cyclone-hit area were more likely to count on wage labour for their livelihood, they would not derive the same benefit from having additional children and tend to limit the number.

This observation is also relevant to the findings associated with the *family dependency index*, which put greater negative pressure on fertility intentions on respondents from the cyclone-hit village than on those from the flood-hit village, for whom this determinant had a positive influence.

The *livelihood diversification index* was strongly associated with influencing respondents in the cyclone-hit village to plan to have another child and also had a positive influence among respondents in the flood-hit village. In both villages, respondents from households that had a strong *agricultural income ratio* were more likely to intend to bear additional children in the future.

Model 2 reveals that all of the *impact determinants* associated with extreme climate events had significant negative influences on the fertility intentions of respondents who had witnessed Cyclone Fani or floods in 2019. Respondents from both villages were less likely to intend to have another child if their households had experienced impacts on agriculture, aquaculture, livelihood, housing, food security, and health. The model fit information suggests that the impacts associated with floods had a more significant negative effect on fertility intentions than the impacts associated with Cyclone Fani.

Model 3 which is indistinguishable between areas hit by cyclones and floods reveals that the fit of data into the model greatly improved than *model 1*, and the direction and the magnitude of some determinants that were considered separately for *model 1* and *model 2* changed slightly. Most importantly, the magnitude of the impact of extreme climate events in 2019 on household well-being dimensions greatly increased than that in *model 2*, indicating that the impacts of climatic events played a significant role in determining the fertility intentions of women in conjunction with the determinants of household vulnerability.

Table 7.9 presents the findings of mean variations with categorical determinants and correlation coefficients for continuous determinants, the outcome of which is to reveal the mean desired number of children for the respondents from each village. The aim of this analysis by mean score variation and correlation was to determine the extent to which the mean number or the coefficient of the desired number of children changed with the change in the determinant. As presented in Table 7.9, the impact of the 2019 flood on the dimensions of household well-being was significant in determining the desired number of children women would like to have before menopause, while none was significant in response to the impact of the cyclone Fani in 2019. Respondents from the flood-hit village were more likely to desire an increased number of children if their household had witnessed the impacts on agriculture and aquaculture, livelihood, housing, food security, and health (Table 7.9).

Table 7.9 The desired number of children of women respondents in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*), based on the determinants associated with the vulnerability of households and the experience of the 2019 cyclone/floods.

Determinants	**Desired number of children Mean (SD)/correlation coefficient**			
	Cyclones	**p-value**	***Floods***	**p-value**
Primary income sources				
Farming	2.23 (.609)	.640	3.13 (1.10)	**.026**
Fishing	2.24 (.591)		2.93 (.977)	
Agricultural wage labour	2.13 (.701)		3.41 (1.13)	
Non-agricultural wage labour	2.18 (.521)		2.58 (.961)	
Health shock				
No impact	2.07 (.495)	**.000**	3.04 (1.13)	**.016**
Infant mortality	2.23 (.598)		2.64 (.965)	
Severe diseases	2.47 (.747)		3.31 (1.10)	
Psychological distress	2.21 (.781)		2.98 (1.03)	
Severe injury or physical disability	2.00 (.555)		3.30 (.939)	
Assistance received				
No assistance	2.13 (.612)	.210	2.97 (1.01)	**.099**
From friends or relatives	2.27 (.648)		2.91 (1.08)	
From government or NGOs	2.15 (.611)		3.27 (1.08)	
Agriculture is the major source of staple food				
No	2.17 (.636)	.952	3.10 (1.08)	.352
Yes	2.18 (.604)		2.97 (1.03)	
Family dependency index (FDI)	.079	**.082**	.061	.178
Livelihood diversification index (LDI)	.072	.101	.089	**.089**
Agricultural income ratio	.068	.117	–.054	.209
Number of extreme events	–.235	**.000**	.255	**.000**
Impact on agriculture and aquaculture				
No	2.22 (.604)	.197	2.89 (1.03)	**.002**
Yes	2.12 (.647)		3.34 (1.05)	
Impact on livelihood				
No	2.19 (.599)	.740	2.87 (1.06)	**.005**
Yes	2.16 (.652)		3.27 (1.01)	
Impact on housing				
No	2.18 (.619)	.827	2.83 (1.02)	**.000**
Yes	2.17 (.632)		3.38 (1.03)	
Impact on food security				
No	2.19 (.574)	.663	2.77 (.982)	**.001**
Yes	2.16 (.662)		3.24 (1.07)	
Impact on health				
No	2.14 (.512)	.161	2.74 (.947)	**.000**
Yes	2.25 (.821)		3.80 (.955)	

Notes: Mean and standard deviation for categorical determinants; correlation coefficient for continuous determinants. Figures are highlighted in **bold** to indicate their significance level (*p-value*) at 5% and 10%.

Source: Household Survey, 2019–2020.

A multinomial logit model was used to explore how the determinants of vulnerability and the impact of household well-being dimensions determined the timing of next birth. Further analysis of multinomial logistic regression (Table 7.10) suggests that all *impacts* of the 2019

Table 7.10 Multinomial logit model results: parameter estimates for women who intend to have another child soon/later in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*), based on the determinants associated with the vulnerability of households and the experience of the 2019 cyclone/floods.

Determinants	***Cyclones* (N=119) Coefficient**		***Floods* (N=113) Coefficient**	
	Have another soon *vs* very soon	**Have another later *vs* very soon**	**Have another soon *vs* very soon**	**Have another later *vs* very soon**
Primary income sources				
Farming (ref.)				
Fishing	–.262	–2.842*	——	——
Agricultural wage	.542	–1.967		
labour	.331	–1.810		
Non-agricultural				
wage labour				
Assistance received				
No assistance (ref.)				
From friends or	.015	.297	–.193	.576
relatives	.474	–.115	–.708	–1.448
From government				
or NGOs				
Agriculture is the major source of staple food				
No (ref.)				
Yes	.399	.140	–1.920**	.484
Family dependency index (FDI)	1.236	1.219	1.743***	1.756***
Livelihood diversification index (LDI)	3.306	1.982	–2.727	–.408
Agricultural income ratio	1.683	1.436	3.268*	2.930
Number of extreme events	–.260	–.416	–.176	.005
Impact on agriculture and aquaculture				
No (ref.)	1.807**	2.731***	.975	2.318**
Yes				
Impact on livelihood				
No (ref.)				
Yes	.946	2.835**	1.779*	2.542***
Impact on housing				
No (ref.)				
Yes	2.985***	2.443**	1.025	2.327
Impact on food security				
No (ref.)				
Yes	1.191	3.526***	2.098**	1.889**
Chi–square statistics (likelihood ratio)	87.311***	79.538***		
Log–likelihood	171.718	159.375		
AIC	231.718	207.375		
BIC	315.092	272.832		
R^2 (Nagelkerke)	58.6%	57.5%		

Notes: Reference group for the timing of the next birth is "have another very soon". *** p < .01, ** p < .05, * p < .10; Note: Health shock and health impact determinants were excluded due to their lower cases.

Source: Household Survey, 2019–2020.

cyclone/floods on households influenced respondents from both villages to plan to have another child, and that more of these respondents aimed to have their future child "later", after three years. *Vulnerability*-related determinants had a variety of influences across the two villages, and the broad tendency was for respondents in the cyclone-hit village to want to have another child later, based on vulnerabilities, whereas those in the flood-hit village generally wanted to have another child sooner.

The comparisons of model fit in Table 7.10 based on AIC and BIC suggest that household vulnerability and impact-related determinants have a more significant effect on the respondents' intentions of spacing in the flood-hit area than in the cyclone-hit area. Other calculations (refer *Table C11, Appendix C*) revealed that the age of the mother and the number of her living children also influenced respondents' intentions for spacing. Although older women with a higher number of children were generally found to want to delay the next birth, the difference was not significant in both areas.

7.5 Demographic, economic, social, and extreme climate events determinants and fertility intentions

This section focuses on one of the questions associated with the objectives of this research, as stated in Section 1.3: "to examine the extent to which fertility intentions are determined by demographic, economic, and social determinants and by extreme climate event-related determinants." A two-step regression procedure was used to address the unobserved determinants associated with extreme climate events-related as well as the demographic, social, and economic determinants that typically influence the fertility intentions of women of reproductive ages. Extreme climate events-related determinants were included in the second step of the regression modelling to see how the model fit improved after including such determinants . This approach can help in identify the extent to which unexplored extreme climate events-related determinants, which can be linked to child mortality, gender preference, household vulnerability, contraceptive access, and birth timing, can critically affect the fertility intentions of women. It is crucial to create and distinguish between dependent and independent determinants to carry out the two-step regression procedure. Demographic, economic, social, and extreme climate events determinants were described earlier in Chapter 4, Tables 4.7 and 4.8.

7.5.1 Demographic, economic, and social determinants affecting fertility intentions (*model 1*)

As presented in Table 7.11, two binary probit models were used to understand the extent to which extreme climate events-related determinants shaped the fertility intentions of the survey respondents: *Model 1* considers demographic, economic, and social determinants *Model 2* includes extreme climate events-related determinants with the determinants of *Model 1* (Table 7.11). The model fit with data was assessed using the AIC and BIC.

Comparing the AIC and BIC results for *Model 1* reveals that demographic, economic, and social determinants were more significant in explaining the variations in fertility intentions of women living in the flood-hit area. That said, out of nine determinants, six and four determinants were significant in explaining the variations in fertility intentions of the respondents in the cyclone-hit and flood-hit villages, respectively. Three significant determinants the village respondents had in common were age, education, and the number of children: all were negatively associated with the respondents' desire to have another child in the next three years. Contraceptive use, frequency of husband's migration, and the time to the closest hospital were negatively associated with the respondents' desire to have another child in the cyclone-hit area. In the flood-hit area, the duration of the husband's migration was significantly negatively associated with the respondents' intent to have another child. In other words, given an increasing number of months of spousal separation due to their husband's migration for their livelihood, respondents in the flood-hit area were less likely to intend to have another child.

Though the results associated with land area per capita were not significant, the higher coefficient values suggest that respondents who owned larger properties were less likely to have another child. Households with farmland were more likely to be better off and require fewer children to help support the family. However, farmers in the cyclone-hit village could not use their land for agricultural production due to salinity in soil and water. According to the Soil Resource Development Institute (2010), the land area affected by salinity in Bangladesh—83.3 million hectares in 1973—was 105.6 million hectares in 2010. Research has shown that the intrusion of salt water into soil in the country's coastal areas has a serious and lasting adverse impact on crop production (Alam et al., 2017; Das et al., 2020). Given the loss of land

Table 7.11 Probit regression results: demographic, economic, social, and extreme climate events-related determinants shaping women's fertility intentions in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Determinants	**Coefficient**			
	Cyclones		***Floods***	
	Model 1	**Model 2**	**Model 1**	**Model 2**
Demographic, economic, and social determinants				
Age				
18–24 (ref)				
25–34	–1.286***	–1.300***	–1.381**	–1.302*
35–49	–2.366***	–2.398***	–3.062***	–3.375***
Education				
No schooling (ref)				
Primary school	–.492*	–.315	–.075	.060
Secondary school	–.932***	–.966***	–.084	.049
Higher secondary school	–7.816	–7.342	–2.002***	–2.009***
Number of children alive				
One (ref)				
Two	–.750***	–1.668***	–1.321*	–1.358
Three and more	–1.127***	–3.701***	–2.108***	–3.006***
Currently using any contraceptives				
No (ref)				
Yes	–.518**	–.698**	–.005	.177
Health				
Poor (ref)				
Fair	.037	.319	–.125	.361
Good	–.118	–.066	–.056	.274
Land area per capita (ha)	–3.332	–5.036	–3.904	–2.554
Frequency of husband's migration	–.389**	–.505**	–.074	–.031
Duration of husband's migration (months)	–.026	.012	–.305**	–.374**
Time to closest hospital (minutes)	–.009**	–.009*	–.040	–.036
Extreme climate event-related determinants				
Perceptions of extreme climate events				
No (ref)				
Yes		–.320		.007
Frequency of extreme climate events				
One (ref)				
Two		–1.362**		.302
Three and more		–1.192**		.965
Household vulnerability to future extreme events				
Low (ref)				
Moderate		1.225**		.949**
High		.979**		.542
Failure to access contraceptives with extremes				
No (ref)				
Yes		1.299***		.141
Timing of first birth with extreme climate events				
There was no disaster (ref)				
Before a disaster		.341		–.478
During or after a disaster		.074		.059
Risk of child death with extreme climate events				
No (ref)				
Yes		1.361***		.877**
Gender preference with extreme climate events				
Daughter (ref)				
Son		.322		.646*
Constant	3.609***	2.849***	5.062***	3.029*
Chi–square statistics	247.971***	294.307***	178.440***	203.605***
Log–likelihood	–83.896	–60.728	–70.843	–58.261
AIC	197.792	171.455	171.686	166.521
BIC	253.985	265.110	223.322	252.582

Note: *** p < .01, ** p < .05, * p < .10. *Source*: Household Survey, 2019–2020.

productivity experienced by those living in the cyclone-hit village, households in this area may both value and rely on land less. However, having additional children could be a potential strategy to deal with the adverse impacts of extreme climate events, especially for households with land less or without a land.

Further calculations were used to explore the mean differences in desired number of children by categorical determinants and to explore the associations between numerical determinants, their correlation coefficients were calculated (Table 7.12). Since most women desired to have at least two children, the outcome variable was not normally distributed and further regression analysis adjusting multiple controls was not helpful. However, it was found that respondents' desired number of children was associated with demographic, economic, and social determinants. Of the demographic, economic, and social determinants, only one, "the number of children alive" was significant for the cyclone-hit area, while five determinants were significant for the flood-hit area. According to the findings, the number of desired children increased with an increase in women's age in the flood-hit village and the number of children alive in both villages. As expected, respondents in the flood-hit area who had received little schooling intended to have a greater number of children than their counterparts who had undertaken and/or completed higher secondary schooling. Moreover, the number of desired children was higher among respondents in the flood-hit area who were using contraceptives during the survey, presumably because they had postponed their childbearing for a short duration and would resume soon to achieve the desired number.

Table 7.12 Desired number of children of women respondents by demographic, economic, social, and extreme climate events determinants in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

Determinants	**Desired number of children**			
	Cyclones		***Floods***	
	Mean (SD)/correlation coefficient	**p-value**	**Mean (SD)/correlation coefficient**	**p-value**
Demographic, economic, and social determinants				
Age				
18–24 (ref)	2.07 (.347)	.211	2.17 (.581)	**.000**
25–34	2.23 (.680)		3.08 (.984)	
35–49	2.18 (.691)		3.47 (1.101)	
Education				
No schooling (ref)	2.13 (.510)	.267	3.20 (1.088)	**.014**
Primary school	2.29 (.657)		3.21 (1.040)	
Secondary school	2.14 (.657)		2.71 (.911)	
Higher secondary school	2.12 (.670)		3.08 (1.288)	
Number of children alive				
One (ref)	1.85 (.446)	**.000**	1.91 (.296)	**.000**
Two	2.19 (.465)		2.42 (.794)	
Three and more	2.72 (.786)		3.48 (.958)	
Currently using any contraceptives				
No (ref)	2.26 (.674)	.216	2.83 (1.061)	**.047**
Yes	2.15 (.608)		3.13 (1.050)	
Health				
Poor (ref)	2.13 (.618)	.699	3.21 (.999)	.095
Fair	2.21 (.646)		3.03 (1.031)	
Good	2.18 (.616)		2.88 (1.109)	
Land area per capita (ha)	–.083	.144	–.063	.342
Frequency of husband's migration	–.056	.321	.024	.718
Duration of husband's migration (months)	–.084	.137	.084	.204
Time to closest hospital (minutes)	–.015	.786	–.066	.320
Climatic extreme-related determinants				
Perceptions of extreme climate events				
No (ref)	2.27 (.696)	.127	2.88 (1.067)	.283
Yes	2.14 (.596)		3.07 (1.059)	
Frequency of extreme climate events				
One (ref)	2.51 (.697)	**.000**	2.17 (.707)	**.000**
Two	2.00 (.336)		2.82 (.840)	
Three and more	2.06 (.594)		3.37 (1.080)	
Household vulnerability to future climatic hazard				
Low (ref)	2.11 (.708)	.252	3.17 (.960)	.320
Moderate	2.26 (.703)		2.89 (1.001)	
High	2.14 (.558)		3.07 (1.154)	
Failure to access contraceptives with extremes				
No (ref)	2.03 (.504)	**.000**	2.77 (.956)	**.000**
Yes	2.61 (.746)		3.81 (.973)	
Timing of first birth with extreme climate events				
There was no extreme climate event (ref)	2.26 (.635)	**.024**	3.14 (1.095)	.264
Before an extreme climate event	2.10 (.594)		3.07 (1.116)	
During or after an extreme climate event	2.02 (.595)		2.87 (.947)	
Risk of child death with extreme climate events				
No (ref)	2.03 (.496)	**.019**	2.50 (.855)	**.000**
Yes	2.22 (.652)		3.26 (1.059)	
Gender preference with extreme climate events				
Daughter (ref)	2.07 (.601)	**.031**	3.27 (1.002)	.072
Son	2.23 (.630)		2.97 (1.070)	

Source: Household Survey, 2019–2020.

7.5.2 Extreme climate events determinants and women's fertility intentions *(model 2)*

According to the AIC results in *Model 2,* as presented in Table 7.11, the model fit improves when extreme climate events-related determinants are included with the determinants of *Model 1*. Including extreme climate events-related determinants in *Model 2* did not change the direction or the significance level of the determinants in *Model 1*; however, the magnitude of a number of determinants changed a little. Four determinants related to extreme climate events were significant for the respondents in the cyclone-hit area, and three were significant for the respondents in the flood-hit area. Household vulnerability to future extreme climate events and the risk of child death were common significant determinants for both villages. In both cyclone- and flood-hit areas, respondents were more likely to plan to have another child if they perceived their households would be moderately or highly vulnerable to a future extreme climate event and if they perceived an increased risk of child mortality associated with such an event. This finding suggests that the desire to have additional children may be a demographic adjustment for highly vulnerable households to the adverse effects of cyclones or floods, with children considered an asset that can increase the household's ability to cope with the stress induced by extreme climate events and to adapt to a changing climate.

Households in Chadnimukha that were highly vulnerable to and adversely affected by past cyclones may be particularly aware of how helpful it can be to have children with sufficient physical strength to help speed the recovery process. Those households who are only moderately vulnerable to future cyclones or floods may not have experienced massive loss and damage affecting their socio-economic conditions, such that the reproductive goals of the women of the households are not affected. The latter part of this Chapter (refer to Section 7.6) triangulates quantitative and qualitative findings to more effectively identify the ways in which the vulnerability of households to extreme climate events can influence the fertility intentions of women.

In addition to household vulnerability, frequency of events, access to contraceptives, and gender preferences influenced fertility intentions. The frequency of cyclones experienced by women was negatively associated with the intention of respondents from Chadnimukha to have another child, indicating that women with increased experiences of cyclones were less likely to have another child. However, these respondents were more likely to have another child if they had failed to access contraceptives due to cyclones. In the flood-hit area, gender preference as a response to extreme climate events was a significant determinant of respondents' fertility intentions: those who perceived that sons rather than daughters can help during flood events were more likely to plan to have another child.

Most extreme climate events-related determinants were significant for the mean variations of the desired number of children in both villages. Table 7.12 shows that the timing of first birth coinciding with extreme climate events was significant for the respondents living in the cyclone-hit village, and indicates that only those who had experienced no extreme climate events before, during, or after the birth of their first child intended to have additional children. Three determinants were common and significant for both villages: the frequency of extreme climate events, the failure to access contraceptives, and the risk of child mortality. The increased frequency of cyclones was associated with a decrease in the intended number of children; in contrast, the increased frequency of floods was associated with an increase in the number of children respondents planned to have. In both villages, respondents intended to have more children if they perceived that extreme climate events carried the risk of child mortality.

7.6 Extreme climate events, the perceived behavioural control determinants and fertility intentions: findings from factor analysis and in-depth interviews

The theory of planned behaviour (TPB), as introduced in Sections 2.5 and 2.6, identifies three components that shape the inentions of an individual, one of which is *perceived behavioural control*. A review of the literature on the theory of planned behaviour and its relationship to disasters-fertility (Ajzen, 1991; Ajzen, 2005; Fishbein & Ajzen, 2010; Ajzen & Klobas, 2013; Arnocky et al., 2012; De Rose & Testa, 2015) informed the development of 13 statements that were included in the household survey to deduce the ways in which extreme climate events influenced respondents' perceived behavioural control. Respondents from both villages who intended to have another child in the next 3 years were asked to note the degree to which their decision to have a child was based on the circumstance in the statement; their responses, grouped into percentages for each statement, are presented in Table 7.13. The reliability of the scale items was checked through Cronbach's Alpha, and the results (.636 for the cyclone-hit village and .797 for the flood-hit village), suggest that the scale items have relatively high internal consistency. In addition, the dimensionality of the scale items was explored further by factor analysis, as shown in Table 7.14.

Table 7.14 presents a rotated component matrix of factor analysis conducted in two parts. The extraction method involved principal component analysis and the rotation method employed Varimax with Kaiser normalization. The factor analysis extracted four components from responses from women in the cyclone-hit village (Table 7.14). *Component 1* includes three strongly loaded statements according to the results in Table 7.13 (statements 7, 8, 9) which indicated that, for the respondents of Chadnimukha, the decision about whether to have a child in the next three years depended on the anticipated loss and damage from future climatic events and the support received from governments, non-governmental organisations, and relatives. The descriptive statistics presented in Table 7.13 suggest that the fertility decisions of respondents from both villages were essentially driven by the anticipated loss and damage that could occur from future extreme climate events. Moreover, these decisions, in both villages, depended only a little or not at all on support received from the government and others. This finding suggests that the experience and perception of different extreme climate events could have differential effects on households, including, but not limited to, their effect on fertility. Generally speaking, planning to have additional children may be a demographic adjustment and coping method for vulnerable households to respond to the adverse effects of climate-induced extremes, particularly in the absence of government-designated social security.

Table 7.13 Descriptive statistics of perceived behavioural control items in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

The decision about whether to have children can depend on a number of circumstances. For example, how much could your decision about whether to have a child in the next three years depend on…

Items	**% *Cyclones* (N=119)**				**% *Floods* (N=113)**			
	A lot	**Quite a lot**	**A little**	**Not at all**	**A lot**	**Quite a lot**	**A little**	**Not at all**
1. Your household's present financial situation.	16.8	51.3	29.4	2.5	6.2	66.4	24.8	2.7
2. The employment opportunities of your partner.	24.4	47.1	28.6	/	10.6	69.0	20.4	/
3. The tendency of your partner to migrate for work.	58.8	21.0	12.6	7.6	41.6	32.7	4.4	21.2
4. The number of months in a year your partner stays out of home.	70.6	17.6	11.8	/	42.5	31.0	8.0	18.6
5. The uncertainty of being affected by an extreme climate event.	79.8	18.5	1.7	/	69.0	26.5	2.7	1.8
6. The loss and damage resulting from previous extreme climate events.	77.3	16.0	5.0	1.7	67.3	28.3	3.5	.9
7. The anticipated loss and damage from a future extreme climate event.	71.4	18.5	9.2	.8	71.7	23.9	.9	3.5
8. The relief and support your household can receive from Govt and NGOs.	3.4	14.3	33.6	48.7	/	3.5	61.1	35.4
9. Social support your household can receive from relatives and neighbours.	6.7	7.6	31.9	53.8	/	3.5	39.8	56.6
10. The uncertainty of being displaced due to an extreme climate event.	16.8	40.3	30.3	12.6	.9	21.2	58.4	19.5
11. The (lack of) availability of health facilities during/after an extreme climate event.	27.7	51.3	20.2	.8	/	60.2	37.2	2.7
12. The perceived adverse health effects of an extreme climate event.	47.1	45.4	5.9	1.7	39.8	59.3	/	.9
13. The perceived risk of losing a child during or due to an extreme climate event.	70.6	23.5	4.2	1.7	66.4	33.6	/	/
Cronbach's Alpha	.636				.797			

Source: Household Survey, 2019–2020.

Table 7.14 Rotated component matrix of factor analysis in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*).

	Component *Cyclones*				**Component** *Floods*		
Items	**1**	**2**	**3**	**4**	**1**	**2**	**3**
Your household's present financial situation.	–.170	**.842**	–.036	–.046	**.670**	.035	–.119
The employment opportunities of your partner.	.097	**.855**	.065	.073	**.699**	.118	–.383
The tendency of your partner to migrate for work.	.437	**.717**	.218	.089	**.807**	.290	–.159
The number of months in a year your partner stays out of home.	.452	**.497**	.389	.124	**.821**	.283	–.260
The uncertainty of being affected by an extreme climate event.	.274	.039	**.798**	–.005	.106	**.967**	.089
The loss and damage resulting from previous extreme climate events.	.015	.114	**.877**	.226	.106	**.948**	.057
The anticipated loss and damage from a future extreme climate event.	**.587**	.227	.394	.274	.041	**.938**	.143
The relief and support your household can receive from Govt and NGOs.	–**.863**	–.160	.020	–.039	–.067	.235	**.645**
Social support your household can receive from relatives and neighbours.	–**.737**	.083	–.313	.155	–.288	–.124	**.767**
The uncertainty of being displaced due to an extreme climate event.	–.236	.089	.176	**.642**	.318	.191	**.647**
The (lack of) availability of health facilities during/after an extreme climate event.	.041	.261	–.079	**.740**	**.769**	–.085	.256
The perceived adverse health effects from an extreme climate event.	.233	–.239	.251	**.693**	**.658**	.097	.331
The perceived risk of losing a child during or due to an extreme climate event.	.515	–.106	.021	**.558**	**.821**	–.087	.061
KMO	.684				.665		
Bartlett's Test of Sphericity: Chi–Square (p)	603.048 (.000)				1149.206 (.000)		
Variance explained (%)	68.16				69.87		

Source: Household Survey, 2019–2020.

Component 2 is strongly loaded by four statements (statements 1–4) according to the results in Table 7.13 which identified the influence of the financial condition of households and the employment opportunities and migration of husbands on fertility decisions of respondents in the cyclone-hit village. It has been established by studies in countries similar to Bangladesh, such as Nepal (Adhikari, 2010), Ghana (Ahinkorah et al., 2021), and Brazil (Tejada et al., 2017), that women's fertility and preferences to have additional children are determined by the wealth status of their households. Existing migration-related research conducted in Bangladesh shows that migration is considered a response to environmental disruptions (Gray & Mueller, 2012; Mallick & Vogt, 2012; Penning-Rowsell et al., 2012) and seasonal poverty (Khandker et al., 2012). In the northwestern part of Bangladesh, around 36 percent of poor households migrate every year during lean periods to cope with seasonal deprivation (Khandker et al., 2012). This research of populations in Chadnimukha and Lamagaon has found that short-term migration to nearby urban areas, especially during the dry season, is a common livelihood option for men in the cyclone-hit village. The interpretation of focus group discussions with men and in-depth interviews with women revealed that men usually migrate for two to six months, depending on the type of work they do. Most work as agricultural and non-agricultural wage labourers in the dry season (October–March). Most non-agricultural wage labourers migrate for at least six months to brickfields located in nearby sub-districts/districts. This short-term labour migration of men leads to a decrease in fertility, because the husband's absence dramatically reduces the frequency of sexual intercourse within a marriage—a key proximate determinant of fertility (Bongaarts et al., 1984; Lindstrom & Saucedo, 2002; Bongaarts & Potter, 1979).

The two statements that were used in *Component 3* (Table 7.13, statements 5 and 6) reflect the effects of extreme climate events on fertility behavioural control. According to the results presented in Table 7.13, when setting their fertility intentions, respondents from the cyclone-hit village primarily considered the effects of the last extreme climate event(s) on their households and the uncertainty of being affected by the next one. Crop failure, loss, and damage all have negative repercussions on the socio-economic conditions of households, and, at worst, lead to poverty (Quiroga & Suárez, 2016). The losses and damage incurred, either economic or non-economic, can vary depending on the event. A study in Bangladesh, for example, showed that both economic and non-economic losses and damage due to the last extreme climate events were higher in the cyclone-prone areas than the flood-prone areas, because multiple hazards were causing relatively longer problems in the cyclone-affected areas (Bhowmik et al., 2021). Qualitative findings from the in-depth interviews support the quantitative results associated with *Component 3*. Some women reported that they prefer going to their parent's homes or other safe locations when they are pregnant and the delivery date is approaching. They related the adverse impacts of cyclones to that preference. Some of them claimed that their future planning was likely to be impacted by their previous experiences with and their perceived risk of cyclones.

One woman from the cyclone-hit village, aged 24 years with two children, clearly indicated that her experience of cyclones factored into her fertility planning:

> *I will temporarily leave the village to a safe location when I am pregnant again. There are many challenges in this village. The risk of a cyclone is one of them; it can come anytime, affecting my health and the baby's in the womb. Both of us can be at risk of severe injury and death. Before the last birth of my daughter, I went to the Shyamnagar sub-district and rented a house to live there until I gave birth safely.* (Participant 6, IDI, cyclone-hit village *of Chadnimukha*)

A statement from another in-depth interview participant from the same village, a woman aged 26 years with two children, reflects the way in which her perception of future cyclones influences her planning:

> *The occurrence of cyclones is increasing in our village. People who experienced the Cyclone Aila in 2009 are constantly afraid of experiencing another such devastating storm. For example, most of the households in our village do not want to completely rebuild their houses because think another terrible cyclone will come. We must think twice about the next occurrence of a devastating cyclone before we plan to do anything* [emphasis in original] *in the future.* (Participant 7, IDI, cyclone–hit village of Chadnimukha)

Therefore, it can be suggested that the fertility intentions of these women are very likely to be determined by the effects of extreme climate events.

Component 4 for the cyclone-hit group includes four strongly loaded statements (Table 7.13, statements 10–13), highlighting the effects of extreme climate events on displacement, health, and child mortality on fertility intentions.The majority of respondents reported that they considered the risk of being displaced due to a cyclone “a little” to “a lot” when setting their fertility intentions. Many respondents in the cyclone-hit village had experienced displacement due to Cyclone Aila in May 2009. A total of 123,000 people were displaced from four severely affected upazilas in Satkhira (Shyamnagar and Assasuni) and Khulna (Dacope and Koyra) districts; 30 percent were from Shyamnagar upazila (Islam & Hasan, 2016). Following this cyclone, it was reported that approximately 100,000 people were still living on embankments in the early months of 2010 (Islam & Hasan, 2016). The component also considers the extent to which extreme climate events adversely affect the reproductive health of women and limit their access to health facilities. Inability to access essential healthcare leaves women not only vulnerable to a injury and death but also to reproductive and sexual health problems (Rahman, 2013). In their study conducted in the southern coastal region of Bangladesh, Alam and Rahman (2014) found that, during Cyclone Sidr in 2007, pregnant women were required to travel long distances to healthcare centres, and this proved quite impossible for most of them. Instead, many walked to the nearby cyclone shelters on muddy, slippery roads and gave birth there without the necessary medical support. Ultimately, this study found that women were less likely to access healthcare after extreme events (Alam & Rahman, 2014). Results of the factor analysis of this component also suggest that women are concerned about the risk of child death due to the adverse effects of cyclones. Research has found that women, particularly those living in areas vulnerable to floods and cyclones in Bangladesh, tended to want additional children if they perceived the risk of child death (Haq & Ahmed, 2019).

The factor analysis of the results collected from respondents in the flood-hit village extracted three components (Table 7.14). *Component 1* loads seven statements (Table 7.13, statements 5-7), indicating the effects of the financial condition of the household and of the partner’s migration as well as the effects of extreme climate events on health and child mortality on the fertility intentions of the respondents from Lamagaon. The influence associated with statements 1 to 4 have already been noted (refer to the discussion of *Component 2*, cyclone-hit village, above). Adding to the discussion of the impact of decreased access to health services following an extreme event (refer to *Component 4,* cyclone-hit village) it is worth noting that access to healthcare after a disaster typically worsens due to the lack of transport and available local healthcare facilities (Rezwana, 2017). An additional issue is the damage to healthcare facilities resulting from floods and other extreme events. It is challenging for health providers to provide services to people in need in the context of destroyed infrastructure, disrupted emergency services, broken machines, disruptions to the provision of electricity and water (Paul & Dutt, 2010).

Component 2 for the flood-hit group loads three statements (Table 7.13, statements 1–4 and 11–13) which consider the influence on fertility intentions of the uncertainty of being impacted by an extreme climate event, the loss and damage suffered in past events, and the concerns around future events. Respondents in the flood-hit village were less likely to plan to have another child if they perceived their households to be highly vulnerable to extreme climate events. These findings are confirmed by opinions expressed in the in-depth interviews of women from the flood-hit village. One 23-year-old woman with a daughter explained that she had postponed her original intention to have another child within the following three years due to the adverse impacts of a flood in 2017 flood on her household.

> *No one can predict accurately when a flood (bonna) will come—it is sudden and rapid and affects a household in many ways. The household can lose their standing crops in the field and the crops stored in the home, lose valuable assets and property, and flood can damage the house— either fully or partially. During the flood in 2017, my household lost crops stored in a* gola ghar *[storehouse], and there was partial damage to the wall of the house. We are still in the recovery process; it may take two more years. I am not planning to have another child in three years.* (Participant 8, IDI, flood–hit village of Lamagaon)

It can be said that crop failure due to climate variations and crop loss and damage due to flash floods or cyclones can indirectly affect women's fertility decisions. Studies have shown that crop failure due to floods is associated with induced food insecurity among households (Oskorouchi & Sousa–Poza, 2021), which results in malnutrition of household members (Goudet et al., 2011), and can have particularly harmful effects on the reproductive health of women (Moafi et al., 2018).

The three statements loaded for *Component 3* (Table 7.13, statements 8–10) indicate that the fertility intentions of respondents from the flood-hit village depend very little on the availability of relief/social support and the risk of displacement. It has been argued that insurance and support from the government or non-government organisations to populations vulnerable to extreme flooding in Bangladesh could lessen economic pressure on households and reduce the intention to have additional children (Haq, 2018). However, during focus group discussions in the flood-hit village, some men said that they seldom receive financial or social support after a flood, since their village is so remote and hard for the government and non-governmental organisation to reach to provide relief and distribute aid. It has been additionally argued that, after a disaster in Bangladesh, the financial aid from the government and NGOs received by households is insufficient to achieve long-term benefits such as the development of strategies to cope with future events (del Ninno et al., 2001). Furthermore, the risk of displacement and the tendency to migrate are not as widespread in the flood-hit village as it is in cyclone-hit village. Findings by Gray and Mueller (2012) confirm that floods in Bangladesh are only marginally related to population mobility, but note that it is typically the poor who do migrate. Perhaps for this reason, they concluded that the effects of crop failure on migration were large and significant.

7.7 Conclusion

It is known that demographic, economic, and social determinants play a significant role in shaping women's fertility intentions. This study examined how extreme climate events-related determinants influence fertility intentions. It found that the fertility intentions of respondents from Chadnimukha and Lamagaon tended to differ according to their experiences and perceptions of the extreme events to which their villages were most vulnerable, which confirms that considering the effects of these determinants on fertility intentions adds significant value to the understanding of established determinants.

The following critical determinants—the influence of which differed according to the type of event—were found to influence the decision of women to have additional children: the vulnerability of households, the risk of child death, and the preference for sons. The experience of cyclones and the perception that these are occurring more frequently was more likely to influence women to have children than the experience and perceptions of floods. Results strongly indicate that the fear of the adverse impacts of cyclones suppresses the fertility intentions of women, and the socio-economic consequences of such events further influence intentions to delay having another child.

Households living in cyclone- and flood-prone areas were expected and confirmed to have different vulnerabilities associated with their exposure to, sensitivity to, and adaptive capacity in the face of an extreme climate event. Households that suffered the greatest impacts on agriculture and aquaculture, livelihood, housing, food security, and health during the cyclone or flood in 2019 were found to be most vulnerable. The impact on households of these events in 2019 was significant for both villages, suppressing the fertility intentions of the majority of respondents for a short term. Respondents who reported that household agriculture, livelihood, housing, and food security had been impacted by Cyclone Fani or floods in 2019 were more likely to postpone their next birth for at least two years. Despite this plan to delay, respondents from the flood-affected households also noted that they intend to have additional children in response to the impacts of the flood in 2019. The intention to have more children could be considered either as an insurance mechanism for households against the possible loss of a child/children due to a flood, or as a way of increasing family livelihood and security: children could serve as potential resources to help the family cope with future risks.

Fertility intentions are at the centre of discussions on family planning and they are used to predict the fertility rate of a given country or population. This research established that the occurrence, frequency, and severity of cyclones or floods had varying effects on the intentions of women to have more children, and that the underlying determinants of fertility associated with extreme climate events are distinguishable and have direct and indirect effects. Therefore, impacts to households associated with climate change or extreme climate or weather events should be considered in conjunction with mortality and migration trends when estimating future fertility. It is important to do so because population estimates are widely used and considered by planners and policymakers to determine what services will be needed—and, ultimately, provided—in the future, such as food, water, and energy, as well as health and education. Without a consideration of the effect of climate change and extreme climate events, these planners and policymakers will not have a complete, contemporary picture of fertility to work with.

Chapter 8 Conclusion and Implications for Policy

8.1 Introduction

This chapter concludes the study by summarising the key findings of the research in relation to the research aims and questions and presents relevant policy implications. This research has investigated how extreme climate events influenced the fertility decisions of Bangladeshi women living in Chadnimukha (a cyclone-hit village) in Satkhira (a southwest district) and Lamagaon (a flood-hit village) in Sunamganj (a northeast district). These regions were chosen as case study sites because of their considerable vulnerability to frequent cyclones/floods. Fieldwork undertaken in 2019–2020 collected primary data from married women with at least one child who were living with their husbands at the time. It was found that cyclones and floods both directly and indirectly affected the fertility decisions of these women in different ways, which are summarised here.

8.2 Summary of key findings

As this study delved into the complex relationship between extreme climate events and women's fertility, it first aimed to assess how well the participating women understood the climate event common to their respective villages and then sought to establish differences between the study areas in terms of their vulnerability to climate events. The results indicated that, generally, respondents' perceptions of extreme climate events were consistent with the meteorological records and the perceptions of their male counterparts. Moreover, the cyclone-affected community appeared to be more vulnerable to extreme climate events than the flood-affected community. Key research questions focused on women's fertility outcomes and their intentions to have more children in relation to extreme climate events are discussed here.

8.2.1 Extreme climate events and the fertility of women

The socio-demographic characteristics of women are known to play a critical role in shaping their fertility, and recently the influence of extreme climate events on fertility has been recognised. These findings suggest, broadly, that cyclones or floods that frequently affect rural communities or societies can determine their distinctive socio-cultural settings. Extreme climate events can have an impact on all demographic components underlying population change and it is acknowledged here that an increase in fertility can arise due to unplanned or mistimed pregnancies as a results of a lack of health services, availability and access to contraceptives, and higher child mortality. On the other hand, fertility can decline due to physiological effects, timing of birth, and increased uncertainty of livelihoods, food security, and absence of partners.

This research found that respondents had more children in the flood-hit village (Lamagaon) than did their counterparts in the cyclone-hit village (Chadnimukha). Indeed, there was a greater general reluctance to have more children among the respondents living in the area hit by cyclones. This variation in fertility was consistent with prior knowledge as two study cases were selected to represent high and low fertility regions. However, the cases were not assigned with foregone conclusions in mind; instead, they were chosen to contrast and examine the fertility decisions in response to unique extreme climate events. Most importantly, the experience of extreme climate events and particularly the frequency they were experienced were found to have a significant direct influence on the fertility of women in both areas. Respondents were likely to have fewer children if they had witnessed a greater number of cyclones, in particular. The analysis of data further established that those households that were more vulnerable to past cyclones had fewer children. The specific adverse impacts of cyclones on housing, livelihood, health, and food security made a household vulnerable, increased their poverty, and influenced the tendency of male members to migrate elsewhere for work and be absent from partners for extended periods of time.

It was found that birth complexities and difficulties were more likely to occur during, before, and after cyclones than was the case for floods, influencing the respondents from Chadnimukha to limit childbearing. These results suggest that extreme climate events can have a direct effect on fertility through physiological consequences such events can have, and that these adverse effects were experienced to a greater degree by those living in the cyclone-hit village. Reductions in fecundity due to lack of access to health services, malnutrition, and the poor health of mothers was more likely to be linked to cyclone events than to flooding. In addition, increased salinity in water, experienced by those in cyclone-hit areas, is known to be associated with the poor reproductive health of women and to affect their fecundity through miscarriage and infertility. Moreover, male participants in the focus group discussions noted that the strenuous activities required to repair damage following cyclones increased fatigue among couples and lead to a decrease in sexual activity. Cyclones were also associated with prolonged adverse effects on livelihoods which reduced the adaptive capacity of households and influenced migration decisions. The more frequent migration of males for livelihood reasons was evident in the cyclone-hit area, and was less common in the flood-hit area.

In contrast to the above findings, it was found that, in some cases and for a number of reasons, fertility increased in times of cyclones or floods. This increase was due, in part, to a rise in coital frequency between couples as they hunkered down for extended periods: the extreme climate events affected the economic activities of both women and men and restricted their mobility and entertainment options. It is expected that this closeness is likely to have increased coital frequency between couples, resulting in unplanned pregnancies and subsequent births. Moreover, the occurrence of cyclones or floods was also found to have prompted a rise in the number of unplanned or mistimed pregnancies or births because of their effect on local essential health services, which limited access to contraceptives. Respondents in the flood-hit area were also motivated by another important determinant of fertility—child mortality—to have more children. Child mortality was higher in the flood-hit area, with children drowning during floods, and women from Lamagaon reported that they were more likely to have more children on the death of a child.

8.2.2 Extreme climate events and the fertility intentions of women

Findings strongly indicated that both the experience and perceptions of cyclones influenced respondents to abstain from having or to plan not to have additional children. On the other hand, because both cyclones and floods were perceived to increase the risk of child death, such events were also found to have influenced mothers to have more children to replace those that have died. The majority of respondents living in the flood-hit area wanted to have more children and preferred sons because they felt that boy children could help families tackle the adverse effects of floods and cope with the associated stress. In fact, the respondents from households affected by either cyclones or floods claimed that there were more benefits to having more sons than more daughters, because boys/men were seen to play a more vital role in the recovery and adaptation to climatic events. Generally speaking, it was found that respondents from both villages wanted a greater number of children if they perceived that their households would be vulnerable to future cyclones or floods, and they held the expectation that having more children could help the family adapt to the changing climate.

Further findings demonstrated that the vulnerability of households to extreme climate events had determined the direct and indirect impact of such events on the intentions of women to have more children. Higher levels of household vulnerability to a cyclone or a flood, as determined by the dimensions of their household well-being such as livelihoods, housing, food security, and health, generally suppressed the intention of women to have more children; those who were more vulnerable and who wanted additional children were more likely to plan to delay the next birth. However, it is important to highlight the finding that the majority of respondents in the flood-hit village expressed their intention to have more children if their households had witnessed impacts on any one or all of the dimensions of well-being mentioned above.

8.3 Policy implications for disaster risk reduction and family planning programs

As part of its efforts to achieve its 2030 sustainable development goals, the Government of Bangladesh has targeted regional disparities in fertility rates in order to reduce these rates across the country. This requires changes to be made to relevant policies or new policies to be developed. It is crucial to ensure that any programs that emerge are present and able to function actively in resource-constrained areas, particularly those that are severely impacted by extreme climate events. This section proposes a number of policy implications of the findings and makes some suggestions for practice in respect to disaster risk reduction and family planning programs in Bangladesh.

Different districts of Bangladesh are uniquely vulnerable to climatic disasters including cyclones, floods, droughts, and other temperature-related events. The findings of this research support the notion that the distribution of total fertility rates is not uniform across these districts because of the different climate disasters each experiences. Fertility rates in Bangladesh have typically been attributed to demographic, economic, social, and cultural determinants (Islam et al., 2010; Islam et al., 2003; Alam et al., 2018). To date, no efforts have been made to explore the influence of the risk and impact of extreme climate events such as cyclones and floods, which are unevenly spread across the country, on the variations in fertility rates in divisions or districts of Bangladesh. The present research has demonstrated clear links between extreme climate events and fertility/fertility intentions. To address the regional disparities in fertility rates in Bangladesh and lower rates overall, existing population policy, family planning, and disaster risk reduction programs would benefit from targeting direct and indirect extreme climate event-related determinants identified in this study. These programs should focus on improved health infrastructure, dedicated health support areas and storage facilities in shelters, increasing public awareness about climate risks, understanding and considering household vulnerabilities in order to make informed family planning decisions, and providing recreational options for couples when they are hunkering down.

Political leaders can play a significant role in disseminating and implementing the existing population planning and policies of the Bangladesh government. The active participation is imperative in achieving a better health coverage and ensuring the sustainable development of health programs in rural communities. Findings showed that political leaders (e.g., Upazila Nirbahi Officer, and Union Chairman), government (e.g., community clinics), non-government (e.g., World Vision Bangladesh), and private organisations actively focus on women's reproductive health and child malnutrition in the cyclone-hit area, but less so in the flood-hit region.

Following a disaster in Bangladesh, emergency supplies are typically distributed by the government and disaster relief agencies. These parcels of supplies mostly include rice, biscuits, canned and dried food, tents, building materials, and cash. The aid packages do not include contraceptives or women's hygiene supplies that were reported to be desperately needed. With better recognition of the impact of extreme climate events on reproductive health outcomes, emergency relief distribution programs can help to prevent unplanned and unwanted pregnancies.

This research suggests that multisectoral engagement in disaster management and family planning programs is critical to enabling change in the rates of fertility. Climate change adaptation or disaster risk reduction programs alone cannot enhance adaptive capacity or resilience to extreme climate events. Enhancing an individual's or community's adaptive capacity depends on social and human capital. Developing social and human capital has not been the key focus of either climate change adaptation or disaster risk reduction practices.

Similarly, any changes in fertility depend on an understanding of determinants such as the age of mothers, education, age at marriage, labour force participation, and wealth status, which need to be considered in conjunction with locational disadvantages and exposure to extreme climate events. Therefore, to addressi regional variations in fertility rates there is a need to develop a multisector approach within the public sector and between the public and private sectors.

Disaster risk reduction deals with a range of activities such as building resilient infrastructure, providing early warning systems, taking early action, increasing employment, reducing poverty, ensuring food security and sustainable agriculture. Disaster risk reduction– can significantly increase the socio-economic development of communities, increase their adaptive capacities and resilience to climate change and extreme weather or climate events. This development, together with ensured functioning of adequate resourced family planning programs, can help reduce fertility and child mortality and increase contraceptive access and use, particularly in crises caused by recurring extreme climate events.

8.4 Implications for theory and research on human geography and fertility

8.4.1 Implications for the theory of planned behaviour (TPB)

According to the theory of planned behaviour (Ajzen & Klobas, 2013), perceived behavioural control is one of three components that shapes a person's intentions. This research identified ways in which the fertility decisions and intentions of the respondents of this study were influenced by a sense of perceived behavioural control that was directly and indirectly influenced by their experience of extreme climate events. This study found that respondents, when considering whether and when to have another child, were highly likely to consider the effects of extreme climate events on the well-being of their households, including but not limited to livelihood, food security, migration, health, access to family planning, and child mortality. These findings imply that insights from the theory of planned behaviour can be helpful in the development a comprehensive framework for understanding human behaviour and fertility decisions from the perspective of climate adaptation or disaster (or risk) management. A great deal of empirical research is needed to develop such a theoretical framework.

8.4.2 Implications for research on human geography

This study, with its focus on climate change and population dynamics has significant implications for research in the field of human geography. Climate change has consequences that are irreversible and large in scale. This study contributes to the literature that has shown that the increasing frequency, intensity, and severity of the extreme climate events, in particular, affects demographic determinants of mortality, migration, and fertility, and poses significant challenges for human adjustments in the future. Our world is experiencing dramatic changes in the magnitude, composition, and distribution of its population, and it is likely that these changes will be further complicated by climate change. Although the entire world is affected by climate change, research has shown that the adverse effects on human populations are unevenly distributed across regions, with the people living in poor or low- to middle-income countries, such as Bangladesh, at significantly greater risk (Jiang & Hardee, 2011; Muttarak, 2021).

Researchers, including Entwisle (2021) and Muttarak (2021), have made a case for including demographic perspectives when studying changes to the global environment or climate. This research, based in Bangladesh, takes such a perspective and contributes to a growing understanding of the influence that climate change and resulting extreme climate events have on mortality, migration, and, more specifically, fertility.

8.4.3 Implications for research into the relationship between the COVID-19 pandemic and fertility

It is reasonable to expect that one could extrapolate from the disaster-fertility literature in order to illuminate the likely impact(s) of COVID-19 on fertility. At the time of writing, the world community has already experienced significant effects from numerous COVID-19 variants (e.g., *Alpha, Beta, Gamma, Delta, and Omicron*), all of which have been found to affect the demographic dynamics of mortality (Arolas et al., 2021; Chaudhry et al., 2020; Kontis et al., 2020), migration (Jesline et al., 2021; Shimizutani & Yamada, 2021) and fertility (Berrington et al., 2021; Emery & Koops, 2022). Increased fertility rates associated with the pandemic have been reported in the short and long-term (Anser et al., 2020), but heterogeneous and contradictory effects on both fertility and healthy birth rates can reasonably be expected as a virulent virus works its way through different communities.

It has been argued that the impact of the COVID-19 pandemic on fertility is likely to depend on how societies have evolved in development and at what stage they are in the demographic transition (Aassve et al. 2020). The findings of existing research, described in Chapter 2, reflect how COVID-19, as a biological disaster, can affect the determinants of fertility. The findings generated by this research identified a strongly contextual relationship between specific climate events, as natural disasters, and the fertility of the people exposed to and vulnerable to such events. These insights can inform the direction of future research into the relationship between COVID-19 and other pandemics, as biological disasters, and fertility. As it has been argued that climate change has the potential to affect the transmission of the pandemic (Chen et al., 2021; Rodó et al., 2021; Smith et al., 2021), future work is certainly required to disentangle the complicated interactions between climate change, the COVID-19 pandemic, and human fertility, when more complete, precise, and reliable evidence is available.

8.5 Limitations and future directions of the research

The study presents *five* limitations. *The first* relates to the sampling procedures used to select the case study areas. Unfortunately, it was not possible to follow the systematic random sampling that might be expected to be conducted to select study areas, due to the lack of available data on historical extreme climate events and fertility rates at sub-district, union, or village levels. The availability of such information would have allowed the selection of areas with high and low fertility rates accompanied by high and low vulnerability to extreme climate events. Instead, this study utilised a mixed methods approach, combining the use of vulnerability assessments of districts in Bangladesh and expert interviews to identify and select the study villages.

Second, conducting gender-specific interviews and discussions presented another limitation. The focus group discussions included only males and the household surveys and in-depth interviews were only undertaken only with females. It would be helpful in future research to consider combining the perspectives of males and females in focus group meetings and surveys to explore and clarify the determinants affecting their fertility intentions. Although this study found that decisions about fertility and contraceptive use are made jointly by couples, future studies should compare married males and females to substantiate a complete picture of the decision-making process and to understand to what extent and in what ways extreme climate events influence such decisions. Research is needed to determine the relative degree of influence of husband or wife on fertility and the contraceptive decision-making process.

Third, the ways some questions were asked during the household surveys may have restricted the respondents from offering more nuanced and enlightening answers. In order to collect quantitative data, many of the questions regarding the impact of extreme climate events invited binary responses. Future research could consider allowing for continuous responses with respect to climate impact determinants that could undergo economic assessment, and to undertake a two–stage regression analysis that could offer more illuminating results.

Fourth, the conclusions of this study are limited to the findings from two areas representing typical villages in Bangladesh that were vulnerable to cyclones and floods. Since a village is a small unit of a district, a suggestion for future research would be to include a greater number of villages from a district that would allow larger sample sizes to enable more robust analysis and enhance the representativeness of the findings. This would add depth to the findings and increase the prospects of generalising from them. Both theoretically and methodologically, it would be useful to include areas not vulnerable to extreme climate events for comparison purposes. However, identifying such areas is difficult and impractical in the context of Bangladesh because of the lack of historical disaster records at the village level and the vulnerability of the whole country is vulnerable to disasters. Future research can use geographic information systems (GIS) and difference-in-difference analysis when data becomes available to distinguish between areas vulnerable and those not vulnerable to extreme climate events. This could be applicable to other contexts, particularly in developed countries.

Finally, the research is also limited because the associated hazards of cyclones or floods were not considered in the research objectives. The cyclone-hit village witnessed multiple hazards, including storm surge, flooding, extreme winds, and salinity in water and soil. The flood-hit village reported experiencing flash floods, droughts, and hailstorms. This study primarily focused on the impacts of cyclones or floods, because these events were typically experienced in the study villages and because each village had experienced a particularly severe and destructive cyclone/flood in 2019, which allowed for a more direct comparison of the impact of the event on the fertility of the communities. Future research would benefit from investigating the effects of multi-hazards to understand the ways and extent to which they influence fertility decisions, both individually and collectively.

This study suggests future direction for research into the effects on fertility/fertility decisions of natural hazards (e.g., geophysical, hydrological, climatological, meteorological, and biological) and human-made and technological hazards (e.g., conflicts, industrial accidents, environmental degradation, and pollution). Notably, of the biological hazards, the COVID-19 pandemic is an exceptional one that can well be expected to have short- and long-term consequences and affect changes in mortality, fertility, and migration in Bangladesh and in other countries. Projections of changes in population structure and policies in Bangladesh should consider the effects of both the pandemic and climate change (including extreme climate events and variations).

8.6 Recommendations

This research suggests specific recommendations based on the empirical findings for areas hit by cyclones and floods. This research identified increased household vulnerability with respect to livelihood strategies, social networks, water, and climate variability in both villages and found that families in the cyclone-affected area were particularly vulnerable. As these vulnerabilities can determine a woman's health, well-being, and fertility decisions, specific interventions or strategies can and should be undertaken to improve livelihood options, facilitate social networking, ensure safe drinking water, and increase awareness of the adverse effects of and approaches for coping with extreme climate events.

In Bangladesh, community clinics offer services in mother and newborn health care, reproductive health and family planning, the Expanded Program on Immunisation (EPI), nutrition knowledge and micronutrient supplementation, and health care. These clinics are run under a participatory model, and are easily accessible for the population. Therefore, these clinics should be at the front line of the government's health initiatives in Bangladesh, particularly those addressing fertility. This is especially strongly recommended for the region hit by floods in this study, which is currently underserved by government community health services. Moreover, non-governmental organisations focused on the health and well-being of populations should facilitate their interventions to target deprived populations who are also subject to extreme climate events, and make special efforts to reach those living in remote and flood-hit areas.

The provision of increased livelihood options, recreational activities, and contraceptives during extreme climate events, particularly floods, can help avoid the incidence of unwanted pregnancies. The lack of access to contraceptives and reproductive health services during extreme climate events is a major driver of increased fertility that can be proactively addressed at many levels of government. In addition, governments can reduce the need women feel to have more children (to support the future economic requirements of the family) by distributing adequate financial and non-financial support following extreme climate events and, in turn, stemming any sharp declines in the socio-economic status of households. This support has been found to be particularly important to reduce the need for additional children for households living in flood-hit areas.

8.7 Conclusion

Climate change is causing extreme climate events to become more common and severe throughout the world, and their effects on the reproductive health and fertility of women are evident, contextual, and individual. In developing countries in which agriculture is the main economic driver and the rural population relies heavily on natural resources for food and livelihoods, climate change and related extreme climate events affect women's fertility on a spatial and temporal scale. This study has demonstrated a number of ways in which climate impact drivers, including extreme climate events, can affect food production, livelihood, health, and household well-being and, in turn, fertility. It is vitally important for human geographers and social demographers to consider the influence that extreme climate events have been shown in this study to have on determinants relating to fertility and reproductive health such as access to health services, availability of family planning services, risk of infant mortality, malnutrition, and poor maternal health.

This research has provided a greater understanding of why fertility varies among women in different regions in Bangladesh by looking beyond the usual determinants of fertility to include the effects of extreme climate events. This empirical research has established the importance of 'pragmatic research' in conducting fertility studies in the context of extreme climate events that can explain fertility decisions and total fertility rates by going beyond the established demographic, economic, social, and policy contexts. The results of this research have significant implications for all countries, especially those in which the decline in fertility rates are not proceeding as expected and cannot be explained by existing socio-economic, demographic, and policy determinants. Future research should aim to test these results by conducting similar studies in larger populations and cross-cultural settings, targeting areas affected by adverse climatic, biological, human-made and technological events.

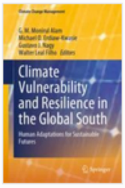
This research on extreme climatic events and fertility has provided an in-depth look into the effect climate has on fertility outcomes, the various ways in which people respond to climate-related disasters. As the number and intensity of extreme climate events rises, the perceived need by a family experiencing such events to have a certain number of children can be affected directly and indirectly. These findings make a strong case for incorporating extreme climate events in the estimates of projection models in relation to the composition, distribution, and size of populations in developing countries. Countries undergoing a demographic transition should investigate the impact of extreme climate events on demographic determinants to identify the reasons behind any change in the pace of fertility decline, especially when these are evident in some areas and not others. Furthermore, given the undeniable effects of extreme climate events on fertility, there is an argument that these effects must be incorporated into disaster risk reduction and population policies.

The main conclusion that can be drawn is that each type of extreme climate event and each community is unique and that each type (e.g., cyclones or floods) can determine to what extent fertility decisions will change and in what direction fertility rates will trend, given the experience, perceptions, and vulnerability of a given community to such an event. Such events can also affect the underlying direct and indirect determinants that influence reproductive outcomes. Considering climate determinants in fertility studies can broaden our understanding of fertility behaviour, as such determinants are not the same as established demographic determinants and change over time and space.

Appendices

Appendix A. Book chapters (published in Springer & Routledge)

1. Ahmed, K. J., & Tan, Y. (2021). *Assessing and mapping spatial variations in climate change and climatic hazards in Bangladesh.* In Alam, G. M. M., Erdiaw-Kwasie, M. O., Nagy, G. J., Filho, W. L. (Eds), Vulnerability and resilience in the global south: Human adaptations for sustainable futures (pp. 465-486). Springer, Netherlands. https://doi.org/10.1007/978-3-030-77259-8_24



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Assessing and Mapping Spatial Variations in Climate Change and Climatic Hazards in Bangladesh

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Chapter
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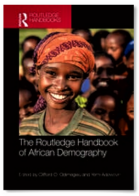
Abstract

Climate change and the frequency and severity of climatic hazards vary significantly by region. There is a pressing need for increased understanding of spatial discrepancies in climate change and climatic hazards within a country and the mapping of areas that require resources to enhance resilience and achieve adaptation and sustainable development goals. This chapter synthesises relevant literature to understand spatial variations in climate change and climatic hazards across Bangladesh. We used data on disaster records from the Emergency Events Database (EM-DAT), administered by the Centre for Research on the Epidemiology of Disasters (CRED), to analyse vulnerability to climatic hazards (relating to storms and extreme temperatures, for example) and hydrological events such as floods, across 64 administrative districts of the country. The climate-change literature confirms that dramatic variations in temperature and rainfall change are unevenly distributed within Bangladesh. CRED's disaster records reveal an uneven geographical distribution of vulnerability to different administrative

2. Ahmed, K. J., & Tan, Y. (2022). *The disaster-fertility nexus in the context of Sub-Saharan African countries*. In Odimegwu, C. O, Adewoyin, Y. (Eds.), Handbook of African demography (pp. 363-380). Routledge, United Kingdom. https://www.taylorfrancis.com/chapters/edit/10.4324/9780429287213-25/disaster-fertility-nexus-sub-saharan-african-countries-khandaker-jafor-ahmed-yan-tan?context=ubx&refId=f3dde301-cf76-4441-a9c8-9a379b339a1b



Chapter

The Disaster-Fertility Nexus in Sub-Saharan African Countries

By Khandaker Jafor Ahmed, Yan Tan

Book The Routledge Handbook of African Demography

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ABSTRACT

Natural disasters, especially those resulting from climate change (climate extremes and variations), are likely to increase in frequency and intensity. There is a pressing need for research on how natural and human-made disasters affect human fertility's behavioural aspects. This chapter addresses those effects in Sub-Saharan Africa (SSA), with its total of 48 countries. Since the mid-20th century, the world has seen a remarkable decline in the global total fertility rate (TFR), from 5.5 children per woman in 1950 to 2.49 in 2015.

Appendix B. Conference presentations (at PAA, IPC IUSSP, and APA)

1. Ahmed, K. J., Tan, Y., & Rudd, D. (2022). Climate extremes and women's fertility intentions: A comparative study in two areas hit by cyclones and floods in Bangladesh. Presented (oral) for the session 'Fertility Intentions and Plans in Context' at the **Population Association of America Conference**, 6-9 April 2022.

PAA2022
April 6-9, Atlanta, Georgia

PAA 2022 Annual Meeting
SUBMISSION SITE

Climate extremes and women's fertility intentions: A comparative study in two areas hit by cyclones and floods in Bangladesh

Khandaker Jafor Ahmed, Yan Tan, Dianne Rudd[1]
[1]The University of Adelaide, Adelaide, Australia

Understanding the relation between climate extremes and fertility intentions of women in the least developing countries is a compelling issue in research and policy. This study analyses the relationship between fertility intentions of Bangladeshi women *and* climate extreme-related factors: women's perceptions and experience of climatic disasters, vulnerability to climatic disasters perceived by their household members, perceived risks for mortality of children, and gender preference. We employ primary data collected from 544 household surveys and 74 in-depth interviews with married Bangladeshi women with one or more children at the time of the survey. Our findings show that the effects of climate extreme-related factors on women's fertility intentions vary significantly between the study areas. Climatic disasters can motivate or constrain women's intentions to have more children. Socio-demographic characteristics of the female groups under research significantly shape their fertility intentions. Finally, we draw implications for family planning and climate adaption policies in Bangladesh.

PAA2022
April 6-9, Atlanta, Georgia

January 27, 2022

Khandaker Jafor Ahmed

Adelaide
Australia

Dear Khandaker Jafor Ahmed,

The Population Association of America (PAA) is a nonprofit, scientific, professional organizationestablished to promote the improvement, advancement and progress of the human race throughresearch of problems related to human population. The PAA Annual Meeting is a scientificconference which provides a forum for the presentation of scientific papers, workshops, anddiscussion groups on population and related issues.

Your paper "Climate extremes and women's fertility intentions: A comparative study in two areas hit by cyclones and floods in Bangladesh" has been accepted in the session Fertility Intentions and Plans in Context as part of the program for the 2022 Annual Meeting of the Population Association of America, April 6 – 9 in Atlanta, GA, USA.

We look forward to your attendance at the conference. Please contact me at the PAA office if there is any additional information I can provide.

Sincerely,

Danielle R. Staudt
Executive Director

1436 Duke Street, Alexandria, VA 22314
(301) 565-6710 Fax (301) 565-7850
www.populationassociation.org

2. Ahmed, K. J., Tan, Y., & Rudd, D. (2021). How does the households' vulnerability to climate–induced disasters influence women's fertility outcomes and fertility intentions in Bangladesh? Presented (poster) at the **International Population Conference** of IUSSP, 5-10 December 2021.

Hyderabad, India

International Union for the Scientific Study of Population

International Population Conference 2021

IPC 2021

5-10 December

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How does the households' vulnerability to climate-induced disasters influence women's fertility outcomes and fertility intentions in Bangladesh?

Khandaker Ahmed✱, *The University Of Adelaide, Australia*
Yan Tan, *the University of Adelaide*
Dianne Rudd, *The University of Adelaide*

GMT+10:30 (Australia/ACDT). Available at 8 am-8 pm, 8 pm-11 pm local time.

Abstract: Understanding the vulnerability to disasters at the household level and inform approaches to adaptation and mitigation, it is essential considering fertility rates in areas susceptible to climate-induced disasters. Aiming to understand whether the vulnerability to climate-induced disasters at the household level influence women's fertility outcomes (measured as the number of children ever born) and intentions to have additional children, this research conducted household surveys with 544 women (aged 18-49) in flood- and cyclone-affected villages in Bangladesh. The results of the climate vulnerability index reveal that a cyclone-affected village is more vulnerable than a flood-affected village. Comparatively, women living in the flood-affected area had higher fertility outcomes and intentions. We also explored how the households' perceived vulnerability impacts women's fertility outcomes and intentions. Findings confirm that different climate-induced disasters could have differential effects on households, including but not limited to

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2021 International Population Conference
5-10 December Hyderabad, India

Certificate of Participation

Paris, December 14, 2021

To whom it may concern:

This is to confirm that Khandaker Ahmed participated in the **XXIX International Population Conference (IPC2021)**, held virtually from 5-10 December 2021.

Khandaker Ahmed presented the following paper at the Conference:

"How does the households' vulnerability to climate-induced disasters influence women's fertility outcomes and fertility intentions in Bangladesh?", presented in Poster Session 6 on Tuesday December 7, 9:00 - 10:30 UTC.

The IUSSP thanks Khandaker Ahmed for attending this Conference and contributing to its success.

Sincerely,

Mary Ellen Zuppan, PhD
IUSSP Executive Director / IPC2021 Conference Secretary

IUSSP/UIESP Campus Condorcet
9, cours des Humanités, 93322 Aubervilliers cedex, France
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International Union for the Scientific Study of Population
Union internationale pour l'étude scientifique de la population

3. Ahmed, K. J., Tan, Y., & Rudd, D. (2021). Do the experiences and perceptions of climatic disasters influence the fertility outcomes and intentions of women of reproductive ages in Bangladesh? Presented (oral) at the **Asian Population Association** conference, 3-5 August 2021.


The 5th Asian Population Association Conference

Search conference Ctrl+K

Do the experiences and perceptions of climatic disasters influence the fertility outcomes and intentions of women of reproductive ages in Bangladesh?

Khandaker Jafor Ahmed, Yan Tan, Dianne Rudd

The University of Adelaide, Adelaide, Australia

Categories

9. Population and Environment, Climate Change and Sustainable Development

Abstract

Aiming to understand how the experiences and perceptions of climatic disasters influence women's fertility outcomes (measured by the number of children ever born, alive, and desired) and intentions, this research conducted 544 household surveys and 73 in-depth interviews with women in flood- and cyclone-affected villages in Bangladesh. Women's experiences and perceptions of climatic disasters were differently associated with their fertility outcomes and intentions.

Appendix C. Supplementary Tables

Table C1 Cyclone zones and their corresponding hazard factors (refer to Chapter 3).

Cyclone zones	Number of districts	Hazard factor
Non–affected area	42	1
High–wind area	10	2
High–risk area	12	5

Source: Authors' estimation.

Table C2 Cyclone weighting factors for frequency (refer to Chapter 3).

Frequency	Weighting factor
0	1.0
1–4	1.1
5–8	1.2
9–12	1.3
13–16	1.4
17–20	1.5
21–24	1.6
25–28	1.7
29–32	1.8

Source: Authors' estimation.

Table C3 Districts corresponding to cyclone–hazard zones based on hazard scores (refer to Chapter 3).

Hazard scores	Hazard zones	Districts
<2	Non–affected	N1 = 42
		Jhenaidah, Narsingdi, C. Nawabganj, Narail, Sherpur, Narayanganj, Gazipur, Magura, Joypurhat, Lalmonirhat, Munshiganj, Habiganj, Moulvibazar, Kishoreganj, Chuadanga, Meherpur, Panchagarh, Thakurgaon, Rajbari, Kushtia, Natore, Brahmanbaria, Nilphamari, Dinajpur, Kurigram, Faridpur, Jamalpur, Naogaon, Jessore, Bogra, Manikganj, Tangail, Gaibandha, Sylhet, Pabna, Sirajganj, Rangpur, Sunamganj, Rajshahi, Mymensingh, Netrokona, Dhaka
2–3	High wind	N2 = 10
		Khagrachhari, Rangamati, Bandarban, Gopalganj, Shariatpur, Madaripur, Jhalokati, Comilla, Chandpur, Pirojpur
5–9	High risk	N3 = 12
		Lakshmipur, Feni, Satkhira, Bagerhat, Barisal, Barguna, Khulna, Bhola, Patuakhali, Noakhali, Cox's Bazar, Chattogram

Table C4 Historical database for three major climatic hazards in Bangladesh, showing numbers of events in each category (refer to Chapter 3).

District	Flood (depths)		Cyclone (zones)		Totals of events
Chattogram	moderate	17	high–risk	32	49
Cox's Bazar	moderate	17	high–risk	22	39
Rangpur	moderate	14	non–affected	7	21
Rajshahi	mod high	14	non–affected	5	19
Gaibandha	moderate	18	non–affected	7	25
Khulna	moderate	5	high–risk	14	19
Kurigram	moderate	18	non–affected	4	22
Sylhet	high	18	non–affected	5	23
Bhola	moderate	6	high–risk	19	25
Dhaka	high	10	non–affected	9	19
Bogra	moderate	17	non–affected	5	22
Sirajganj	high	13	non–affected	8	21
Noakhali	moderate	6	high–risk	17	23
Barisal	mod high	8	high–risk	10	18
Patuakhali	mod high	4	high–risk	17	21
Netrokona	mod high	11	non–affected	9	20
Pabna	high	9	non–affected	5	14
Nilphamari	moderate	10	non–affected	3	13
Barguna	moderate	2	high–risk	15	17
Mymensingh	moderate	3	non–affected	12	15
Lalmonirhat	moderate	11	non–affected	0	11
Manikganj	mod high	8	non–affected	6	14
Tangail	mod high	7	non–affected	7	14
Satkhira	moderate	6	high–risk	8	14
Naogaon	none	8	non–affected	6	14
Dinajpur	normal	3	non–affected	4	7
Jamalpur	moderate	10	non–affected	5	15
Comilla	moderate	9	high–wind	5	14
Bagerhat	moderate	3	high–risk	10	13
Jessore	none	4	non–affected	5	9
Feni	moderate	8	high–risk	4	12
Sunamganj	extreme	5	non–affected	5	10
Brahmanbaria	mod high	5	non–affected	4	9
Faridpur	moderate	5	non–affected	5	10
Madaripur	mod high	6	high–wind	4	10
Panchagarh	none	3	non–affected	2	5
Moulvibazar	moderate	8	non–affected	2	10
Bandarban	none	6	high–wind	3	9
Thakurgaon	none	2	non–affected	2	4

Habiganj	high	8	non–affected	1	9
Pirojpur	moderate	0	high–wind	7	7
Chandpur	mod high	2	high–wind	6	8
Munshiganj	high	6	non–affected	2	8
Rajbari	moderate	6	non–affected	1	7
Lakshmipur	moderate	4	high–risk	3	7
Natore	high	3	non–affected	3	6
Sherpur	moderate	6	non–affected	0	6
Kishoreganj	extreme	3	non–affected	3	6
Shariatpur	mod high	3	high–wind	3	6
Chuadanga	none	2	non–affected	2	4
Kushtia	moderate	4	non–affected	1	5
Joypurhat	normal	4	non–affected	0	4
Gopalganj	high	2	high–wind	3	5
Jhalokati	moderate	0	high–wind	3	3
Rangamati	none	3	high–wind	1	4
Khagrachhari	none	2	high–wind	1	3
Meherpur	none	1	non–affected	1	2
C. Nawabganj	moderate	3	non–affected	1	4
Narayanganj	high	2	non–affected	0	2
Gazipur	none	0	non–affected	0	0
Narsingdi	moderate	1	non–affected	0	1
Jhenaidah	none	0	non–affected	1	1
Magura	moderate	0	non–affected	0	0
Narail	mod high	1	non–affected	0	1

Source: Author’s estimation using data from EM-DAT (2020).

Table C5 Flood weighting factors for frequency (refer to Chapter 3).

Frequency	**Weighting factor**
0	1.0
1–3	1.1
4–6	1.2
7–9	1.3
10–12	1.4
13–15	1.5
16–18	1.6

Source: Author’s estimation using data presented in Table C2, Appendix C.

Table C6 Hazard scores for all districts, by hazard type (refer to Chapter 3).

District	Flood hazard score (a)	Cyclone hazard score (b)
Jhenaidah	1	1
Narsingdi	2.2	1
C. Nawabganj	2.2	1
Khagrachhari	1.1	2.2
Rangamati	1.1	2.2
Narail	3.3	1
Bandarban	1.2	2.2
Sherpur	2.4	1
Faridpur	2.4	1.2
Jamalpur	2.8	1.2
Narayanganj	3.3	1
Munshiganj	3.6	1.1
Comilla	2.6	2.4
Habiganj	3.9	1.1
Moulvibazar	3.9	1.1
Gopalganj	3.3	2.2
Shariatpur	3.3	2.2
Chandpur	3.3	2.4
Madaripur	3.6	2.2
Gazipur	1	1
Kishoreganj	5.5	1.1
Chuadanga	1.1	1.1
Meherpur	1.1	1.1
Naogaon	1.3	1.2
Jessore	1.2	1.2
Magura	2	1
Panchagarh	1.1	1.1
Thakurgaon	1.1	1.1
Lakshmipur	2.4	5.5
Joypurhat	2.4	1
Rajbari	2.4	1.1
Kushtia	2.4	1.1
Mymensingh	2.2	1.3
Feni	2.6	5.5
Jhalokati	2	2.2
Lalmonirhat	2.8	1
Pirojpur	2	2.4
Natore	3.3	1.1
Brahmanbaria	3.6	1.1
Bogra	3.2	1.2
Nilphamari	2.8	1.1
Manikganj	3.9	1.2
Tangail	3.9	1.2
Dinajpur	2.2	1.1

Kurigram	3.2	1.1
Bhola	2.4	7.5
Patuakhali	2.4	7.5
Noakhali	2.4	7.5
Gaibandha	3.2	1.2
Netrokona	4.2	1.3
Sylhet	4.8	1.2
Pabna	3.9	1.2
Sirajganj	4.5	1.2
Rangpur	3	1.2
Dhaka	4.2	1.3
Cox's Bazar	3.2	8
Sunamganj	6	1.2
Rajshahi	4.5	1.2
Satkhira	2.4	6
Bagerhat	2.2	6.5
Barguna	2.2	7
Barisal	3.9	6.5
Khulna	2.4	7
Chattogram	3.2	9

Source: Author's estimation.

Table C7 Districts corresponding to flood–hazard zones based on hazard scores (refer to Chapter 3).

Hazard scores	Hazard zones	Districts
<2	Non–affected	N1 = 11
		Jhenaidah, Gazipur, Khagrachhari, Rangamati, Chuadanga, Meherpur, Panchagarh, Thakurgaon, Bandarban, Jessore, Naogaon
2–2.9	Normal flooding	N2 = 25
		Magura, Jhalokati, Pirojpur, Narsingdi, Chapai Nawabganj, Mymensingh, Dinajpur, Bagerhat, Barguna, Sherpur, Faridpur, Lakshmipur, Joypurhat, Rajbari, Kushtia, Bhola, Patuakhali, Noakhali, Satkhira, Khulna, Comilla, Feni, Jamalpur, Lalmonirhat, Nilphamari
3–3.9	Moderately high flooding	N3 = 21
		Rangpur, Bogra, Kurigram, Gaibandha, Cox's Bazar, Chattogram, Narail, Narayanganj, Gopalganj, Shariatpur, Chandpur, Natore, Munshiganj, Madaripur, Brahmanbaria, Habiganj, Moulvibazar, Manikganj, Tangail, Pabna, Barisal
4–4.9	High flooding	N4 = 5
		Netrokona, Dhaka, Sirajganj, Rajshahi, Sylhet
5–6	Extreme flooding	N5 = 2
		Kishoreganj and Sunamganj

Table C8 Factor analysis of perceptions and experiences of women about extreme climate events in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*) (refer to Chapter 6).

Statements	Components			
	Cyclones		*Floods*	
	1	2	1	2
Within the next 5 years, there will be another extreme climate event.	**.927**	.181	**.862**	.017
This extreme climate events will be severe, like the past one.	**.890**	.272	**.938**	.164
The extreme climate events may cause severe damages to house and properties.	**.891**	.240	**.925**	.194
A extreme climate events may cause the deaths of some people.	**.908**	.214	**.914**	.168
I have seen at least one or more extreme climate events within the last ten years.	.133	**.805**	.076	**.880**
I have seen some historical extreme climate events, which caused the deaths of many people, in my lifetime.	.318	**.804**	.190	**.908**
I see extreme climate events from my childhood or from when I have been living here.	.163	**.846**	.050	**.887**
I have several worst experiences of suffering from extreme climate events.	.245	**.816**	.173	**.914**
Cronbach's Alpha	.899		.869	
KMO	.865		.797	
Explained variations (%)	79.5		83.8	

Source: Household Survey, 2019–2020.

Table C9 Generalised linear modelling for younger women (aged 18–34) as sensitivity analysis: parameter estimates of children ever born with associated households' vulnerability related determinants in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*) (refer to Chapter 6).

Determinants	**Coefficient**	
	***Cyclones* (N=214)**	***Floods* (N=157)**
Income sources		
Farming (ref.)		
Fishing	–.311	–.158
Agricultural wage labour	–.304	–.217
Non–agricultural wage labour	–.237	–.181
Health shock		
No impact (ref.)		
Infant mortality	.299**	.163
Severe diseases	1.036***	.773*
Psychological distress	.336*	.040
Physical injury or disability	.096	.080
Assistance received		
No assistance received (ref.)		
Friends or relatives	–.279**	.717***
Government and NGOs	–.063	.625**
Agriculture major source of staple food		
No (ref.)		
Yes	.062	–.323
Family dependency index	.379***	.422***
Livelihood diversification index	.382	2.059**
Land area per capita (ha)	–3.390**	–1.781
Years of schooling of household head	–.024*	–.114***
Ratio of agricultural income to total income	–.051	–1.060*
Ratio of time (minutes) to travel to the nearest health facility during disaster times and other times of the year	–.119*	–1.361
Chi–square statistics (likelihood ratio)	86.352***	50.253***
Log–likelihood	–227.977	–259.986
AIC	491.955	555.971
BIC	552.542	610.984

*** p < .01, ** p < .05, * p < .10

Source: Household Survey, 2019–2020.

Table C10 Generalised linear modelling for younger women (18–34) as sensitivity analysis: parameter estimates of children ever born with associated socio–demographic and extreme climate events–related determinants in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*) (refer to Chapter 6).

Determinants	**Coefficient**	
	***Cyclones* (N=214)**	***Floods* (N=157)**
Socio–demographic determinants		
Age		
18–24 (ref.)		
25–34	.535***	.894***
Education		
No schooling (ref.)		
Primary school	.063	.088
Secondary school	–.034	–.213
Higher secondary school	.303	–.091
Age at marriage		
Before 18 years (ref.)		
On or after 18 years	.012	–.363**
Contraceptive use		
No (ref.)		
Yes	.022	.328**
Health		
Poor (ref.)		
Fair	.135	.239
Good	.070	–.307**
Extreme climate events–related determinants		
Timing of first birth with extreme climate events		
There was no extreme climate event (ref.)		
Before an extreme climate event	–.289***	–.330*
During or after an extreme climate event	–.315***	–.292*
Migration after an extreme climate event		
No (ref.)		
Yes	.007	–.040
Households’ vulnerability to past extreme events		
Low (ref.)		
Moderate	.121	–.113
High	–.346***	–.044
Frequency of extreme climate events		
One (ref.)		
Two	–.689***	.328
Three and more	–.765***	.995***
Perceived risk of child death with extreme events		
No (ref.)		
Yes	.044	.497***
Failure to access contraceptives with extreme events		
No (ref.)		
Yes	.522***	1.310***
Gender preference with extreme climate events		
Daughter (ref.)		
Son	.221***	–.255
Chi–square statistics	184.779***	193.407***
Log–likelihood	–178.763	–188.409
AIC	397.527	416.818
BIC	464.846	477.943

*** p < .01, ** p < .05, * p < .10

Source: Household Survey, 2019–2020.

Table C11 Intentions of the spacing by age and the number of children in villages hit by cyclones (*Chadnimukha*) and floods (*Lamagaon*) (refer to Chapter 7).

Age	Number of children	Specific intentions to have another child (%)					
		Very soon		Soon		Later	
		Cyclones	***Floods***	***Cyclones***	***Floods***	***Cyclones***	***Floods***
18–24	One	50.0	60.0	20.4	10.0	29.6	30.0
	Two	40.0	46.7	60.0	13.3	——	40.0
	Three^{+}	——	20.0	——	40.0	——	40.0
25–34	One	37.0	25.0	40.7	25.0	22.2	50.0
	Two	27.3	30.4	36.4	26.1	36.4	43.5
	Three^{+}	——	34.3	——	22.9	100.0	42.9
35–49	One	——	——	50.0	——	50.0	100.0
	Two	——	——	66.7	——	33.3	——
	Three^{+}	——	50.0	50.0	16.7	50.0	33.3
Total (%)		37.8	38.9	31.1	20.4	31.1	40.7

Source: Household Survey, 2019–2020.

Appendix D. Focus group discussions with male participants

Location: …………………………….

Date…. /…. /….

School of Social Sciences, Department of Geography, Environment and Population

The Impacts of Natural Disasters on Fertility Intentions and Outcomes in Bangladesh

Name of the Researcher: **Khandaker Jafor Ahmed**

Focus Group 1: Village disasters historical timeline

- Can you tell me about the extreme climate events that have happened in the village?
- Together, let us make a list of all the extreme climate events that have happened in the last 20 or 30 years in this village that you can recall. Of the extreme climate events from the past on this list, which do you think were the most devastating for the village? Can you rank the top 10 extreme climate events?

Year	Rank (Rank)	Events/extreme climate events (Events/extreme climate events)	Overall impacts to the community

- Are these extreme climate events happen more frequently now? Was it more frequent in the past?
- Do you think these events will be more frequent and devastating in the future?
- Which particular disaster do you think will occur more frequently in the next 10 years?
- Does this perception of future events affect your plans for the future?

Focus Group 2: Seasonal and occupational calendar

- You all are drawing a seasonal calendar (preferably including Bangla and English month with six seasons) showing the previous and current timing, frequency of occurrences for the following extreme climate events. Use the template provided below.

Table. A template of seasonality calendar.

Name of the hazard																									
	Eng Month	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Bang Month		Mag		Fal		Cha		Bai		Jai		Ash		Sra		Bha		Ash		Kar		Agr		Pou
	Past season																								
	Current season																								
Temperature*																									
Rain**																									
Fog																									
Hailstorm																									
Tornado/or inland storms																									
Flash flood																									
Monsoon flood																									
Cyclone***																									
Tide***																									
Soil salinity***																									
Groundwater salinity***																									
Surface water salinity***																									
Drought																									
Groundwater arsenic																									

*Average and extreme temperatures (hot and cold, summer, winter, autumn and spring)

**Average and extreme rainfall (monsoon, pre-monsoon, post monsoon and dry seasonal rainfall)

***only for the coastal region

- Identifying the occupational season or when the villagers do these occupations using the template:
- What are the most common and diverse types of occupation/livelihood options of the villagers at different times of the year?

Table. A template of occupational calendar.

Occupation	**Months**											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1. Farming												
2. Fishing												
3. Agricultural wage labour												
4. Non–agricultural wage labour (earthwork, a construction worker, a transport worker, rickshaw puller but not owned)												
5. Self–employed (taxi, carpenter, rickshaw, van, boat, CNG owner)												
6. Industrial worker (garments and factories)												
7. Petty trade (small scale)												
8. Business (large scale												
9. Migration (within the district)												
10. Migration (outside the district)												
11. Migration (foreign)												
12. Other (specify)												

- Are these livelihood options vary with the changes in seasons or events of extreme climate events?
- What are the livelihood options during and immediately after the times when a natural disaster occurs?

Focus Group 3: Hazard mapping

- Creating a map of the village and surrounding area to promote discussion and ‘map’ the answers:
- Have you noticed any changes in temperature and rainfall in recent years?
- What are the main hazards faced by the community? Are those same as in the past (10 / 20 / 30 years ago)?
- How did the people in the community cope with the hazards in the past (10 / 20 / 30 years ago)?
- Which areas were most at hazards risk in the past? Are they the same areas now? Why (not)?
- Are there seasonal variations in the hazards identified?
- Can you identify the areas more exposed to natural hazards*****?
- Which structures or buildings would be most at risk?
- Which people would be most at risk from different hazards? Why?
- What would be the impacts if different hazards occurred on the lives and livelihoods of the villagers?
- How do people currently cope with the impacts of the specific hazards identified?
- Are the current strategies working? Are they sustainable?
- Are there places in the village/community that are safe from hazards?
- Are there safe places to protect specific things (e.g. to store food, to shelter livestock etc.)?
- Are you prepared for the prospective natural disaster? How are you prepared?
- Do you think the village as whole is prepared?
- Does this perception of future events affect your plans for the future? What plans might be changed or affected?

***** Areas at risk from different types of hazard should be identified and shaded in colours and symbols can be used to indicate different types and levels of risk.

Focus Group 4: Children as Helping Hand/Burden During Disaster

- What do you people do when there is a extreme climate events? Can you tell us the daily activities you people (men and women) do during a extreme climate events?
- Please tell us in detail what a men or women do during the extreme climate events.
- Please tell us something about the children activities during a extreme climate events. Do/can they go to school? What else they do during extreme climate events?
- Can you describe how the young children give hand during a extreme climate events? Does the contribution differ from a male to a female? What are the activities done by a male or a female during a extreme climate events?
- Of the male and female, who does contribute more? Keeping the extreme climate events perspectives and benefits of children, who – male or female child – is more helpful?

Focus Group 5: Climate change perceptions

- Please tell us about the changes in temperature and rainfall in this region in the last 30 years. How did you find the changes in temperature and rainfall? Did they increase, decrease, or fluctutate?
- What do you think about the future changes in temperature and rainfall? Will they increase, decrease, or fluctuate?
- Do you find the changes in seasonal temperature and rainfall? What are the changes in rainy season and summer? Are there any changes in their duration? Please describe.

Appendix E. Key informant interview (KII) with experts

Location: …………………………….
Date…. /…. /….
School of Social Sciences, Department of Geography, Environment and Population
The Impacts of Natural Disasters on Fertility Intentions and Outcomes in Bangladesh
Name of the Researcher: **Khandaker Jafor Ahmed**

KII with Upazila Nirbahi Officer (UNO) and Project Implementation Officer (PIO)

- Please, tell us something about the Upazila: major features, major challenges, socio–cultural contexts, and environmental issues.
- Please, tell us in detail about the extreme weather events occur in the locality.
- What was the recent most extreme weather events faced by the locality? What was the loss and damage?
- How many people have been affected and what are the damages of public property and infrastructure? How many death tools?
- How did the upazila administration act before, during and after the disaster? How NGOs played role there?
- What were the most devastating extreme climate events affecting the upazila over the last five years? What are the loss and damage estimates? Is there any accounting? How and from where those can be obtained?
- What is the most vulnerable locality in the area (e.g., Unions and villages) in terms of loss and damage, and regular vulnerability to extreme climate events? How to reach there? Is there any contact of the Union Chairman for communication?
- Can we get the statistics of population/birth rate in the selected unions and villages before and after a disaster? If yes, from where we can access the information?

KII with NGO Health Representative and Family Planning Officer/Worker

- Can you please tell us about the present health facilities (number of hospitals, clinics, doctors, family planning workers etc.) in the locality?
- Are the facilities available and enough when there is an emergency like a natural disaster? What happens then with the public or private health infrastructure? How the government authority (Upazila Health Officials) respond to the crisis?
- How do you reach the poor and remote dwellers? Or, how they reach you to access the facilities provided?
- What are the obstacles for them to access the resources and facilities? Is their access same throughout the year or is it different during the disaster times?
- We would like to know a bit about the contraceptive access and facilities in the locality. Can you tell us how men and women think about the contraceptive use? What are the contraceptive methods available in the locality? Which one is the most popular, convenient, and affordable? How do you encourage people to use contraceptive? Are there any incentives to encourage people? With men and women, who use the contraceptive mostly? Can you tell us the reasons why they use mostly?
- Can you tell us about the contraceptive access and use during a disaster? Can they access and use during the disaster? When people mostly use the contraceptive: before, during, or after a disaster?
- Can you tell us the influences to use contraceptive? Who does influence a men or women to use contraceptive?

Appendix F. Household survey with married women

Extreme climate events and women's fertility decisions: A study in two areas hit by cyclones and floods in Bangladesh

School of Social Sciences, Department of Geography, Environment and Population
Name of the Researcher: **Khandaker Jafor Ahmed**
Student ID: a1747516

Date of Survey	
Survey ID	
Interviewer Name	

Geographic information of the household

District	☐ Satkhira ☐ Sunamganj
Sub-district/Upazila	☐ Shyamnagar ☐ Tahirpur
Union	☐ Gabura ☐ Sreepur South
Village	☐ Chadnimukha ☐ Lamagaon

Section A. Socio-demographic characteristics of respondents and their households

I. Household socio-demographic information

Household members [Include those who are temporarily absent in the household]	Age [write '00' if less than a year]	Gender M=1, F=2	Religion **Code 1**	Who is the Head? Please put √ where it goes	Relationship with the household head? **Code 2**	Years of schooling
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
Total family size						

Code 1: Islam=1, Hinduism=2, Buddhism=3, Christianity=4, Others (specify)

Code 2: 1**.** Household head, 2. Husband/wife, 3. Son/daughter, 4. Brother/sister, 5. Father/mother, 6. Father-in-law/mother-in-law, 7. Son-in-law/daughter-in-law, 8. Brother-in-law/sister-in-law, 9. Grandchildren, 10. Nephew/niece, 11. Others

Section B. Dimensions of climate vulnerability index (CVI)

I. Structure of the house

Parts of house	Materials used						
	Mud/earth	Wood	Metal sheet (tin/plastic)	Thatch/straw	Bamboo	Cement/concrete	Burnt bricks
Wall							
Roof							
Floor							

II. Livelihoods strategies and household income

1. Household income sources

Codes	Per month income from the sources		Number of members engaged in each source
	Most important source	Second source	
1. Own farming			
2. Lease farming			
3. Sharecropping			
4. Livestock			
5. Fishing			
6. Agricultural wage labour			
7. Non-agricultural wage labour (earth work, construction worker, transport worker, rickshaw puller (but not owned)			
8. Self-employed (taxi, carpenter, rickshaw, van, boat, CNG owner)			
9. Low salaried employee (clerk, peon, primary school teacher)			
10. Government services			
11. Professional/technical (engineer, high school and college teacher)			
12. Industrial worker (garments and factories)			
13. Petty trade (small scale)			
14. Business (large scale)			
15. Pension			
16. Remittances (in the country)			
17. Remittances (foreign)			
18. Other (specify)			
Is the first source of income: 1. Temporary/casual, 2. Seasonal or stable?			
Is the second source of income: 1. Temporary/casual, 2. Seasonal or stable?			
Total income per month			

2. Is agriculture the main source of income in your household? 1. Yes, 2. No
3. Does anyone in your household migrate to work? 1. Yes, 2. No

4. If Yes, Who?....................
5. And, for how many days a year? ....

III. Farm land and size

1. Does your household have agricultural land? 1. Yes, 2. No (if No, go to Q3)
2. Is the land adjacent to your home or is somewhere else? (*If somewhere else please specify how far away*....................)
3. Size and form of land ownership

Form of land	Size of the land (ha)	
Total cultivable agricultural land owned		
Total dwelling-house/Homestead land owned		
Total Non-cultivated Land		
Total cultivable agricultural land rented/ share-cropped/ mortgaged in		
Total cultivable agricultural land rented/ share-cropped/ mortgaged out		
Total operating land (ha) (1+2+3+4-5)		

IV. Health

1. How much time in minutes does it take you to get to the nearest health facility? ....
2. Is there any death of household members in the last 5 years? 1. Yes, 2. No
3. Have you seen others villagers losing children due to an extreme climate event? 1. Yes, 2. No
4. Do you experience any infant mortality in the last 5 years? 1. Yes, 2. No
5. Have any household members had any health issues in the 5 years (2014-2018) prior to 2019 due to a change in temperature and rainfall or an extreme event for which they needed to consult a doctor or visit the hospital? 1. Yes, 2. No
6. If Yes, what are they?
   1. infant mortality, 2. severe diseases, 3. psychological distress, 4. severe injury or physical disability
7. Did you/your household face any stress due to the changes in temperature and rainfall? 1. Yes, 2. No
   Are there any disabled people in your household? 1. Yes, 2. No

V. Social Networks

1. Have you received any support or assistance (cash, food, cloth etc.) in the past few months? 1. Yes, 2. No
2. From whom: 1. Government 2. NGOs 3. Friends and relatives 4. Other (specify)
3. Have you assisted someone with any support or assistance (cash, food, cloth etc.) in the past few months?
   1. Yes, 2. No
4. Have you borrowed money from your friends or relatives in the last 12 months? 1. Yes, 2. No
5. Have you borrowed money from moneylender in your village in the last 12 months? 1. Yes, 2. No
6. Have you borrowed money from NGOs in the last 12 months? 1. Yes, 2. No
7. Have you lending money to your friends or relatives in the last 12 months? 1. Yes, 2. No

VI. Food

1. Does your household have adequate food the whole year? 1. Yes, 2. No
2. Are there times during the year that your household does not have enough food? 1. Yes, 2. No
3. How many months a year does your household have trouble getting enough food? ....
4. Do you do homestead gardening? 1. Yes, 2. No
5. Does agriculture provide the primary source of income to buy food for your family? 1. Yes, 2. No
6. Do you get enough food for the year from your farm? 1. Yes, 2. No
7. Is the amount of food produced on your land decreasing? 1. Yes, 2. No
8. Did you lose any land due to (an) extreme climate event(s)? 1. Yes, 2. No

VII. Water

1. Is potable water available for your household throughout the year? 1. Yes, 2. No
2. Do you collect rainwater for drinking throughout the year? 1. Yes, 2. No
3. Do you own a tube well? 1. Yes, 2. No
4. If No, where do you get your drinking water?
   1. Other's private tube well, 2. Community tube well, 3. Pond, 4. Canal, 5. River, 6. Sea, 7. Rainwater harvesting, 8. Others (specify) ....
5. Is/Are these source(s) safe? 1. Yes, 2. No
6. How long does it take you (minutes) to reach a safe source of drinking water? ....
7. In the past year, did you experience or see any conflicts over water in your community? 1. Yes, 2. No

VIII. Natural disasters

1. How many floods/cyclones have you experienced in the last 5 years? ....
2. Was anyone in your household injured in this/these extreme climate event(s)? 1. Yes, 2. No
3. Did anyone in your household die in this/these extreme climate event(s)? 1. Yes, 2. No
4. Was there any death or injury of livestock in this/these extreme climate event(s)? 1. Yes, 2. No
5. Did you experience the full or partial loss of your house or property during a recent extreme climate event? 1. Yes, 2. No
6. Did you receive a warning before the last extreme climate event happened? 1. Yes, 2. No

IX. Climate variability

1. Have you observed any change in summer temperature? 1. Yes, 2. No
2. Have you observed any change in winter temperature? 1. Yes, 2. No
3. Have you observed any change in total rainfall? 1. Yes, 2. No
4. Have you observed any change in monsoon rainfall? 1. Yes, 2. No
5. Have you observed any change in the winter month's rainfall? 1. Yes, 2. No
6. Do you think that extreme climate events happen more frequently? 1. Yes, 2. No
7. Do you think that recent extreme climate events are more severe than those you experienced in the past? 1. Yes, 2. No

Section C. Experiences and perceptions of climate change and extreme climate events

I. Changes in temperature and rainfall

1. What changes do/did you observe?

	What are the changes?			
	Increase	Decrease	Fluctuation	No change
Temperature				
Changes in temperature (overall) in the last 20 years				
Changes in summer temperature in the last 20 years				
Changes in winter temperature in the last 20 years				
What changes in temperature did you observe in the last 20 years?				
What changes in temperature do you expect in the next 20 years?				

Rainfall									
Changes in total rainfall in a year									
Changes in monsoon rainfall in the last 20 years									
Changes in winter month's rainfall in the last 20 years									
What changes in rainfall did you observe in the last 20 years?									
What changes in rainfall do you expect in the next 20 years?									
Changes in seasons in the last 20 years	Delay in onset	Early cessation	Delay in cessation	Early in onset	Delay in onset, early in cessation	Dealy in onset, delay in cessation	Early in onset, early in cessation	Early in onset, delay in cessation	No change
What changes do you find in the rainy season?									
What changes do you find in summer?									
Observed patterns in rainfall in the last 20 years			Short period, high rains		Long period, high rains		Short period, little rains		Long period, little rains
How do you identify the rainfall intensify?									
Observed patterns in summer in the last 20 years			Short period, high temperature		Long period, high temperature		Short period, low temperature		Long period, low temperature
How do you identify the temperature patterns in summer?									

II. Perceptions and experiences of extreme climate events

No.	Items	Responses (Please, put the √)				
		Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Perceptions						
1	Within the next 5 years (2020-2024), there will be another extreme climate event that could be as destructive as one of the past.					
2	The extreme climate event will be severe, like the ones in the past.					

3	The extreme climate event may cause severe damage to houses and properties.					
4	The extreme climate event may cause the deaths of some people.					
Experiences						
5	I have experienced at least one extreme climate event within the last ten years.					
6	In my lifetime, I have experienced some historic extreme climate events which caused the deaths of many people.					
7	I have experienced extreme climate events, either in my childhood or since I started living here.					
8	I have suffered during/from (an) extreme climate event(s).					

III. The frequency, intensity, and the severity of the impact of extreme climate events

	Responses				
	Low		**Medium**	**High**	
	Very low	Low	Medium	High	Very high
Frequency of extreme climate events in the last 10 years (2009-2018)					
The severity of extreme climate events in the last 10 years (2009-2018)					
Negative impacts of extreme climate events on household well-being in the last 10 years (2009-2018)					
Difficulties in coping with the adverse effects of extreme climate events in the last 10 years (2009-2018)					

IV. Impacts of extreme climate events

1. Impacts of cyclones or floods in 2019 on the dimensions of household well-being:

    1. To what extent did your household suffer the damage or loss of standing crops in the farm or fish/shrimp in the shrimp ponds during the extreme event in 2019? 1. No impact, 2. significant impact
    2. To what extent were the natural or non-natural sources of income for your household affected and associated with a loss of employment and a decrease in total income for at least 3 months? 1. No impact, 2. significant impact
    3. To what extent did the extreme climate events in 2019 cause partial or complete structural damage to your house which required significant repairs? 1. No damage, 2. Partial, 3. Complete damage
    4. Did your household face a shortage of staple food for at least 3 consecutive months following the extreme climate event(s) in 2019? 1. Yes, 2. No
    5. Did the extreme climate event(s) in 2019 affect the health of any of the members of your household (e.g., injury, psychological distress, diseases, malnutrition) at any time, from during the event to 3 months afterward, for which they needed to consult a doctor or visit the hospital? 1. Yes, 2. No
2. How many cyclones or floods have you experienced in the village since you have lived here?
3. Households' vulnerability to extreme climate events in the past ten years (2009-2018), as these events affected the dimensions of household well-being such as agriculture, livelihood, housing, food security, and health?
    1. Low [if any of the dimensions was affected and needed minor repairs or a few days to recover]
    2. Moderate [If any two dimensions were affected or damaged and needed some repairs or a few weeks to recover]
    3. High [If three or more dimensions were affected and needed significant repairs or a couple of months to recover]

4. Considering your households' socio-demographic and economic characteristics and vulnerability to past extreme climate events, to what extent would you think your household is most likely to be vulnerable to future extreme climate events compared with other households in the village? 1. Low, 2. Moderate, 3. High
1. Extreme climate events limit women's economic activity 1. Yes, 2. No
2. Ways of limiting women's economic activities and facing vulnerability

   1. Cannot collect food, fodder, and fiber, 2. Cannot do horticulture around their houses, 3. Challenging to moving to flooding kitchen/garden, 4. Lose scope in agro-based processing activities, 5. Women sit idly at home and have rare opportunities to entertain themselves, and 6. Others (specify)

Section D. Women health and health facilities

I. Women health and facilities

In general, would you say your health is?

- Excellent
- Very Good
- Good
- Fair
- Poor

II. How true or false is each of the following statements for you?

Items	**Responses**				
	Definitely true	Mostly true	Don't know	Mostly false	Definitely false
I seem to get sick a little easier than other people.					
I am as healthy as anybody I know.					
I expect my health to get worse.					
My health is excellent.					

III. Nearest health facilities

	What are the nearest health facilities in this village? **Code 3**	How much time does it take to go to this nearest health facility? (minutes)		How would you normally go there? See **Code 4** (write different codes if different modes of transportation are used)	
		Throughout the year, except for the extreme climate events	During the extreme climate events	Throughout the year except the extreme climate events	During the extreme climate events
1					
2					
3					
4					
5					

Code 3-Health facilities

1. Satellite Clinic, 2. Union health and family welfare centre, 3. Thana health complex, 4. District hospital, 5. NGO health centre, 6. Private clinic/Hospital/Doctor, 7. Other, specify

Code 4-Mode of transportation to go to health facilities

1. Walk, 2. Boat, 3. Rickshaw, 4. CNG, 5. Bike, 6. Bus, 7. Train, 8. Other (specify)

Section E. Fertility outcomes and intentions

(This section is about the married women and her children)

I. Birth order and history of birth of children

Birth order (with ever born children)	What was gender of the child? M=1, F=2	Did you prefer any gender for each birth? M=1, F=2, No preference=3	Date of birth		Timing of birth There was no extreme climate event six months before or after the birth=1 The birth occurred six months or more before an extreme climate event=2 the birth occurred during or six months after an extreme climate event=3	When was the extreme climate events?		Did any of these children die? Please put √, where it goes; if there is *no death*, go to the next section
			Year	Month		Year	Month	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

II. Fertility

1. Age at marriage (years): ....
2. Are you pregnant now? 1. Yes, 2. No (If yes, the number of months you are pregnant....................)
   (*If a woman is pregnant, they will be asked for the intention of next birth*)
3. When (year) was your previous birth (may pick from the previous Table): ....

III. Fertility intention

1. Do you intend to have another child?

   - ☐ Definitely not
   - ☐ Probably not
   - ☐ Probably yes
   - ☐ Definitely yes

2. How many years after your upcoming [if they were pregnant during the survey] or recent birth or from the point of this survey would you like to have another child?

   - ☐ Have another very soon (within a year)
   - ☐ Have another soon (2 years)
   - ☐ Have another later (after 3 or more years)

3. Does your husband also have the same intention? 1. Yes, 2. No, 3. I do not know
4. If you do not want another child, could you please specify the reasons?

   - ☐ Sterilized (either anyone)
   - ☐ Infecund or pregnancy complications after a birth
   - ☐ I do not want more children, no reason
   - ☐ I have desired number of children, no more
5. Do you have any gender preference for the next birth? 1. Yes, 2. No (if **No**, go to Q9)
6. If yes, which gender: 1. Boy, 2. Daughter
7. Which gender of child do you think can help your household during a disaster (e.g., assist in moving to safer places) and help cope with and recover from the disaster? 1. Boy, 2. Daughter, 3. Both

IV. Ideal/desired/intended number of children

1. Have you and your husband ever discussed the number of children you would like to have? 1. Yes, 2. No
2. Ideal/desired/intended number of children for your family: ....
3. Do you think your husband/partner wants the same number of children that you want, or does he want more or fewer than you want? 1. Same number, 2. More children, 3. Fewer children, 4. Do not know
4. How many sons do you want to have? ....
5. How many daughters do you want to have? ....

V. Fertility decision making

1. Who decides to have children: 1. Husband alone, 2. Wife alone, 3. Both husband and wife
2. Who else helps/influences to have children? (*can select multiple responses*)
   1. Mother-in-law, 2. Father-in-law, 3. Brother-in-law, 4. Sister-in-law, 5. Friends, 6. Relatives of parents-in-law, 7. Relatives of my maternal family, 8. Close door neighbor, 9. A neighbor of the village, 10. Others (specify)

VI. Temporary migration of partner

1. Have anyone of the couple ever migrated in the last 5 years? 1. Yes, 2. No
2. If 'Yes', for how many days/months/years: days...................months...................years......…..............
3. Frequency of husband's migration in the last 5 years: ....
4. Duration of husband's migration for each time (average months): ....
5. Has your husband migrated away from your household for any period lasting at least 3 months, due to any extreme climate event or due to the adverse impacts of an extreme event on your livelihood and/or income?
6. Time and causes of migration within country history

Year	After an extreme climate event? Yes=1, No=2	Causes (details, write down please)	
		Push factor	Pull factor

VII. Contraception

1. Do either you or your partner ever use any contraception? 1. Yes, 2. No
2. Who uses mostly? 1. Husband, 2. Wife, 3. Both with a combination
3. If you use, who decides to use contraceptive? 1. Husband alone, 2. Wife alone, 3. Both
4. Who else helps/influences you to use contraceptive?
   1. Husband alone, 2. Wife alone, 3. Both husband and wife, 4. Mother-in-law, 5. Father-in-law, 6. Brother-in-law, 7. Sister-in-law, 8. Friends, 9. Relatives of parents-in-law, 10. Relatives of my maternal family, 11. Close door neighbor, 12. The neighbor of the village, 13. Others (specify)
5. Has failure to access contraceptives due to climate-related extreme events resulted in mistimed, unplanned, or unwanted pregnancies and/or live births? Possible impacts of an extreme event include: decreased availability of local health care facilities, medical relief, and aid; damage and disruption of available health care facilities, damage of medicines and contraceptives stored in family planning facilities; and reduced accessibility of transport systems.
6. Which method (s) are you using?

Methods	**Use** (Please, put √; multiple options apply)		Sources of the method **Code 5**	When do you use mostly? Anytime when other options are unavailable=1 During extreme climate events=2 After extreme climate events=3
	Ever used	Currently		
Female sterilisation				
Male sterilisation				
IUD (Intra Uterine Device)				
Injectable				
Implants				
Oral contraceptive pill				
Condoms				
Lactation amen. method				
Safe period/periodic abstinence				
Withdrawal				
Others (specify)				

Code-5
1. Satellite Clinic, 2. Union health and family welfare centre, 3. Thana health complex, 4. District hospital, 5. NGO health centre, 6. Private clinic/Hospital/Doctor, 7. Grocery shops 8. Local pharmacy 9. Other, specify

Section F. Child mortality and extreme climate events

I. Perceived risk of child loss

1. Did you perceive there would be a risk of child death associated with the occurrence of climate-related extreme events (e.g., by injury, drowning, or waterborne disease) in the village? 1. Yes, 2. No
2. How well do you agree with the following statements?

	Responses				
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Extreme climate events induce mortality regardless of gender and age.					
Children have a higher risk of dying during an extreme climate event.					
Children cannot move independently in an emergency or during an extreme climate event. This makes them vulnerable to injury and death.					
Extreme climate events have adverse effects on the environment that affect child health.					
Extreme climate events impede access to child health care, resulting in child deaths.					

Section G. Planned fertility behaviour and extreme climate events

I. Perceived behavioral control

The decision about whether to have children can depend on a number of circumstances. For example, how much could your decision about whether to have a child in the next three years depend on…

Items	Responses			
	A lot	Quite a lot	A little	Not at all
Your household's present financial situation.				
The employment opportunities of your partner.				
The tendency of your partner to migrate for work.				
The number of months in a year your partner stays out of home.				
The uncertainty of being affected by an extreme climate event.				
The loss and damage resulting from previous extreme climate events.				
The anticipated loss and damage from a future extreme climate event.				
The relief and support your household can receive from Govt and NGOs.				
Social support your household can receive from relatives and neighbours.				
The uncertainty of being displaced due to an extreme climate event.				
The (lack of) availability of health facilities during/after an extreme climate event.				
The perceived adverse health effects of an extreme climate event.				
The perceived risk of losing a child during or due to an extreme climate event.				

Dear *Participant*. *Thank you* very much for expressing your willingness, taking part in this *study, and providing valuable information.*

Appendix G. In–depth interviews with married women

School of Social Sciences, Department of Geography, Environment and Population
The Impacts of Natural Disasters on Fertility Intentions and Outcomes in Bangladesh
Name of the Researcher: **Khandaker Jafor Ahmed**

In–depth Interview Guide for Selected Married Women

These first few questions are about the family structure in your household, this information will expand on what you have already shared during the household survey.

1. How many people are living in your household?
2. Please, tell me about your number of children you have ever had and their birth histories. Please include the details (gender and year) of all births so far, including any children who might have died.
3. (If the participant has mentioned a child who has died) Would you mind telling me the details of when, how, and where you have experienced the death of your child (ren)?
   3a) Has experiencing child mortality made you reconsider the number of children you would prefer to have?
   (*This is an introduction exercise and these questions mentioned above are to confirm the information you provided in the household survey. You are free to share if you miss something or if something is incorrect*.)
4. During the household survey, you have indicated whether you intend to have another child (or not). Can you tell me more about this intention?
5. During the household survey, you talked about the contraceptives you use. Can you tell me what the challenges you face to use contraceptives during or due to a disaster?
6. Do you have any preference for the next birth if you want to have another child (son/daughter and spacing after the last child)? Why do you have these preferences?
7. When people want to have children, they are influenced by many circumstances. Can you tell me what the determinants/circumstances do/did you consider having a child? Do you think these reasons are common for all women in this village?
8. What are the likely advantages/disadvantages of having more children? Are these advantages/disadvantages linked to the effects of extreme climate events?
9. If we have a look at the birth of your children, can you tell me a little bit about the interval between births? Was there any disaster before or after any of these births? Did anything happen with your reproductive health services during or after these disasters? Could you access the health facilities as you could during other times of a year?

These next questions relate to your experiences of extreme climate events

10. Can you tell me the details of any extreme climate events have you experienced? (*Ask about type of disasters and when they occurred)*
11. Thinking about the last disaster that you experienced, what was the impact on your household?
12. What do you and your household typically do when there is any natural disaster? How many days a natural disaster usually last? How many days was it in the last natural disaster?
13. Have you/your household members ever been displaced/temporarily migrated due to and after a natural disaster?
14. What does your partner (husband) do during a natural disaster? (*Does he stay at home? How many days does he stay at home? Does he stay at home more days during the natural disaster compared with other months of the year?*)
15. What about other members of your household? *(Do they go to work or stay at home during a disaster, do children have school or stay at home, and do you keep regular appointments at this time?)*

16. Do/did you have access to health care during and immediately after a natural disaster? (*What are the health difficulties do you typically face during a natural disaster? Can you mention any story when you could not access health facilities during a natural disaster?)*
17. Do your children give you a hand during and after a natural disaster? Can you give some examples of what they do?
18. Do you think there are other benefits during and after a natural disaster of having more children? What are these?
19. Who (son/daughter) could help you more during and after a natural disaster?
20. Can you tell me how many children would you prefer if there were no extreme climate events in the village?
21. Have you noticed other women in the village experiencing child mortality? Do you think this is more likely when there is a natural disaster? Why do you think so?
22. Can you access to contraceptive during a natural disaster? Do you tend to use it during a natural disaster? Do you have any story when you failed to use or did not have access to, contraception during a natural disaster?
23. What do you think about the future – do you think extreme climate events will be more frequent in the future? Do you also think extreme climate events will be more severe in the future? What would this mean for your family and household?

That is all the questions we have today. Is there anything else you would like to add or share? Many, many thanks for your valuable time and information.

Appendix H. Random number of sample generation using research randomizer software

RESULTS

Cyclones-hit area

1 Set of **318 Unique** Numbers
Range: From **1** to **611— Sorted from Least to Greatest**

Set #1

4, 7, 8, 9, 10, 11, 12, 14, 15, 17, 18, 20, 23, 24, 25, 26, 27, 28, 29, 30, 31, 36, 38, 40, 41, 44, 49, 50, 57, 58, 62, 64, 65, 66, 68, 69, 70, 71, 75, 79, 80, 81, 82, 84, 85, 87, 91, 92, 93, 94, 96, 97, 99, 100, 104, 105, 108, 110, 116, 117, 119, 123, 124, 126, 127, 129, 130, 132, 133, 134, 135, 136, 140, 141, 142, 143, 149, 151, 152, 153, 154, 160, 161, 162, 163, 165, 167, 169, 170, 172, 173, 177, 179, 182, 183, 184, 185, 186, 187, 190, 191, 193, 197, 198, 202, 203, 204, 205, 206, 208, 212, 213, 214, 216, 217, 219, 223, 225, 227, 229, 233, 234, 235, 238, 239, 241, 242, 243, 250, 252, 253, 254, 260, 261, 262, 263, 264, 266, 267, 268, 269, 270, 271, 273, 275, 276, 279, 280, 282, 283, 286, 287, 289, 290, 291, 292, 295, 296, 298, 299, 302, 304, 306, 308, 309, 310, 311, 312, 314, 315, 316, 317, 318, 319, 330, 331, 344, 345, 347, 348, 352, 353, 355, 356, 359, 360, 362, 363, 368, 369, 370, 371, 372, 374, 377, 379, 380, 381, 384, 387, 388, 390, 392, 393, 394, 396, 398, 400, 405, 406, 410, 411, 413, 414, 416, 417, 418, 419, 420, 421, 422, 426, 427, 428, 433, 434, 435, 437, 442, 443, 444, 445, 446, 447, 450, 452, 453, 457, 458, 462, 464, 466, 467, 468, 470, 471, 473, 475, 476, 477, 478, 479, 481, 482, 484, 485, 490, 492, 493, 495, 499, 500, 503, 504, 505, 507, 508, 509, 510, 516, 518, 519, 523, 524, 525, 526, 527, 528, 531, 532, 534, 535, 537, 539, 545, 554, 556, 560, 561, 563, 564, 565, 567, 568, 569, 572, 577, 579, 580, 581, 582, 583, 584, 585, 586, 590, 591, 592, 593, 597, 599, 602, 603, 604, 605, 607, 608, 610

RESULTS

Floods-hit area

1 Set of **231 Unique** Numbers
Range: From **1** to **355— Sorted from Least to Greatest**

Set #1

1, 3, 4, 6, 7, 10, 11, 13, 14, 15, 16, 18, 22, 25, 26, 28, 30, 34, 36, 37, 38, 39, 40, 41, 43, 44, 45, 46, 47, 48, 49, 50, 51, 53, 56, 58, 59, 60, 63, 65, 66, 70, 71, 72, 73, 78, 79, 81, 84, 86, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 103, 104, 105, 106, 107, 108, 109, 110, 112, 113, 114, 115, 116, 117, 118, 120, 122, 123, 126, 128, 129, 130, 131, 132, 135, 136, 137, 138, 139, 140, 141, 142, 145, 147, 151, 152, 153, 154, 155, 157, 158, 159, 160, 161, 162, 163, 165, 166, 167, 168, 169, 170, 172, 173, 174, 175, 177, 179, 180, 181, 184, 185, 187, 188, 189, 192, 193, 194, 195, 196, 197, 198, 202, 203, 204, 205, 207, 208, 209, 210, 211, 213, 215, 216, 217, 218, 219, 220, 221, 223, 224, 225, 227, 228, 231, 233, 234, 235, 236, 239, 240, 241, 242, 243, 244, 245, 246, 250, 252, 253, 254, 255, 256, 258, 259, 260, 262, 263, 264, 266, 267, 271, 273, 275, 276, 277, 278, 282, 283, 285, 287, 289, 291, 295, 297, 298, 300, 304, 305, 307, 308, 310, 311, 312, 313, 314, 315, 318, 319, 320, 321, 324, 326, 327, 329, 331, 332, 333, 334, 335, 337, 338, 339, 341, 342, 343, 345, 348, 352, 353

Appendix I. Research ethics approval from the HREC, The University of Adelaide

THE UNIVERSITY of ADELAIDE

RESEARCH SERVICES
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY
THE UNIVERSITY OF ADELAIDE

LEVEL 4, RUNDLE MALL PLAZA
50 RUNDLE MALL
ADELAIDE SA 5000 AUSTRALIA

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CRICOS Provider Number 00123M

Our reference 33463

13 July 2020

Associate Professor Yan Tan
School of Social Sciences

Dear Associate Professor Tan

ETHICS APPROVAL No:	H-2019-077
PROJECT TITLE:	The Impacts of Natural Disasters on Fertility Intentions and Outcomes in Bangladesh

Thank you for your amended ethics application submitted on the 19th of June 2020, requesting a change in co-supervisor from Dr Helen Barrie to Ms Dianne Rudd. Your amendment request has been approved.

The ethics amendment for the above project has been reviewed by the Secretariat, Human Research Ethics Committee and is deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research 2007 (Updated 2018)*.

You are authorised to commence your research on:	14/05/2019
The ethics expiry date for this project is:	31/05/2022

NAMED INVESTIGATORS:

Chief Investigator:	Associate Professor Yan Tan
Student - Postgraduate Doctorate by Research (PhD):	Mr Khandaker Jafor Ahmed
Associate Investigator:	Dr Dianne Rudd

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled Annual Report on Project Status is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/research-services/oreci/human/reporting/. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the information sheet and the signed consent form to retain. It is also a condition of approval that you immediately report anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol or project investigators; and
- the project is discontinued before the expected date of completion.

Yours sincerely,

Ms Samara Jane Mitchell
Secretary

The University of Adelaide

Appendix J. Participant information sheet (focus group discussions, key-informant interviews, household surveys, and in-depth interviews)

PARTICIPANT INFORMATION SHEET FOR FOCUS GROUPS

PROJECT TITLE: The Impacts of Natural Disasters on Fertility Intentions and Outcomes in Bangladesh

HUMAN RESEARCH ETHICS COMMITTEE APPROVAL NUMBER: H–2019–077

PRINCIPAL INVESTIGATOR: A/Prof Yan Tan
STUDENT RESEARCHER: Khandaker Jafor Ahmed
STUDENT'S DEGREE: Doctor of Philosophy (PhD)

Dear Participant,
You are cordially invited to participate in the research project described below.

What is the project about?

This research aims to investigate the impacts of loss and damage to households and villages, including injury and child mortality, from extreme climate events in rural villages in Bangladesh. The study will examine the impacts of these events on women's decisions to intend to have more children or not.

Who is undertaking the project?

Khandaker Jafor Ahmed is conducting this project. This research will form the basis for the degree of Doctor of Philosophy (PhD) at the University of Adelaide in South Australia under the supervision of A/Prof Yan Tan and Dr Dianne Marie Rudd.

Why am I being invited to participate?

You are being invited in a focus group discussion, a semi–structured discussion with eight to twelve people to discuss together a broad range of issues associated with extreme climate events and their impacts on your village. You are an inhabitant of the village selected for this study and have good knowledge of the village and its households. You also may have experiences of extreme climate events (e.g., cyclones or floods) that have hit the village in the last 10 to 20 years. Your valuable information will be used to understand what disasters have occurred in the village, to identify the areas of the village that are vulnerable to disasters, and to consider the likely impact of future disasters to your village.

What am I being invited to do?

The themes of focus group include recording information about the extreme climate events that have occurred in the 10 to 20 years; the seasonal patterns and likely time of the year disasters mostly happen; the village's vulnerability to extreme climate events, and potential of loss and damage in the village from these disasters. There will be three focus groups in your village and you will be invited for any of them. Your participation will be of your own free will. The focus group will be audio–recorded using a digital recording device so that we do not lose any of the information provided. If you agree to participate, you will be asked to sign in a consent form.

How much time will my involvement in the project take?

Each focus group will last long around 90 minutes.

Are there any risks associated with participating in this project?

We do not anticipate any risk associated with your participation in the research project. Your privacy will be maintained, and you have your own free will to choose to not answer any sensitive questions, such as those about loss of life or severe damage in the village. Moreover, you can withdraw your participation at any time during the focus group discussion if you wish. In case of your distress during the focus group, the contact of local family planning worker or health care worker can be provided to you for counselling services.

What are the potential benefits of the research project?

While this research may be of no direct benefit to you, the information you provide helps us to understand the vulnerability of the villages and households in rural Bangladesh. This information, once published, may be of help for local government and non–governmental organizations (NGOs) in future to support Bangladeshi villagers during and after a natural disaster.

Can I withdraw from the project?

Participation in this project is completely voluntary. Upon your interest to participate, you also can withdraw your participation at any time. There will be no effects on you if you choose to withdraw from the focus group or to participate in the study and the information you have provided will be excluded from the research at your request. If you deny or withdraw your participation, it will not affect any local services or benefits you or your family members receive from the family planning workers.

What will happen to my information?

Confidentiality and privacy: All identifying information will be removed from the information you provide and it will remain non–identifiable in the published format. No names of any respondents will be given in the PhD thesis and any other publications. Therefore, the utmost care will be taken to ensure that no personally identifying details are revealed after the information is collected.

Storage: The information you provide will be stored on a computer with a password and in a locked office at the University of Adelaide for at least five years following the date of thesis submission. Only the researchers on the project have access to the information.

Publishing: The research findings will be published as a PhD thesis, academic journal articles and conference papers where no names of any respondents will be identifiable. Non–identifiable socio–demographic factors such as age, gender, and occupation may be provided to validate the quotations of participants but names of participants and villages will not be used.

Sharing: The information collected as part of this project will not be shared with others except researchers and will not be used for any future research project. The transcripts and summary of the results will be provided to participants upon request. However, no raw data or other information about participants will be shared with other participants.

Your information will only be used as described in this participant information sheet and it will only be disclosed according to the consent provided, except as required by law.

Who do I contact if I have questions about the project?

Please, if you have any questions or comments about this research project, feel free to contact

A/Prof Yan Tan, Room G 32, Napier, School of Social Sciences, North Terrace, the University of Adelaide. South Australia 5005, by telephone +614 83133976 or by email at yan.tan@adelaide.edu.au

You can also contact

Dr Dianne Marie Rudd, Room G 34, Napier, School of Social Sciences, North Terrace, the University of Adelaide. South Australia 5005, by telephone +614 83134109 or by email at dianne.rudd@adelaide.edu.au

And

Khandaker Jafor Ahmed, Room G38, Napier, School of Social Sciences, North Terrace, the University of Adelaide. South Australia 5005, by telephone +614 91174392 or by email at khandaker.ahmed@adelaide.edu.au

What if I have a complaint or any concerns?

The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number **H–2019–077**). This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research 2007 (updated 2018). If you have questions or problems associated with the practical aspects of your participation in the project or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator.

If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on:

Phone: +61 8 8313 6028
Email: hrec@adelaide.edu.au
Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, Adelaide SA 5000

Any complaint or concern will be treated in confidence and thoroughly investigated. You will be informed of the outcome.

If I want to participate, what do I do?
If you would like to participate in this focus group please contact Khandaker Jafor Ahmed in person or by phone (+88 01771 85 29 83).
If you want to participate, you will need to sign a consent form to agree to participate in the research before the focus group begins. The questions for the focus group discussion will be provided to you before the day so that you have time to consider the information you may share. It should be noted that there are other activities associated with this project that you, or a family member, may wish to be involved in, including a household survey and in–depth interview. If you choose to be involved in these other activities your information from the focus group may be linked to the survey and/or interview data. Information about these other activities will be given at the focus group.

We thank you for your participation in this important research project.

Yours sincerely,

A/Prof Yan Tan: Principal Supervisor and Investigator
Dr Dianne Marie Rudd: Co–Supervisor
Khandaker Jafor Ahmed: PhD Candidate

PARTICIPANT INFORMATION SHEET FOR KEY INFORMANT INTERVIEWS (KIIs)

PROJECT TITLE: The Impacts of Natural Disasters on Fertility Intentions and Outcomes in Bangladesh

HUMAN RESEARCH ETHICS COMMITTEE APPROVAL NUMBER: H–2019–077

PRINCIPAL INVESTIGATOR: A/Prof Yan Tan
STUDENT RESEARCHER: Khandaker Jafor Ahmed
STUDENT'S DEGREE: Doctor of Philosophy (PhD)

Dear Participant,
You are cordially invited to participate in the research project described below.

What is the project about?
This research aims to investigate the impacts of loss and damage to households and villages, including injury and child mortality, from extreme climate events in rural villages in Bangladesh. The study will examine the impacts of these events on women's decisions to intend to have more children or not.
Who is undertaking the project?
Khandaker Jafor Ahmed is conducting this project. This research will form the basis for the degree of Doctor of Philosophy (PhD) at the University of Adelaide in South Australia under the supervision of A/Prof Yan Tan and Dr Dianne Marie Rudd.
Why am I being invited to participate?
You are being invited in a key informant interview, a semi–structured discussion with government officials or stakeholders to discuss together a broad range of issues associated with extreme climate events and their impacts on the selected areas. You are working in the area selected for this study and have good knowledge of the area and surroundings. You also may have experiences of extreme climate events (e.g., cyclones or floods) that have hit the locality in the last 10 to 20 years. Your valuable information will be used to understand what disasters have occurred in the locality, to identify the areas of the locality that are vulnerable to disasters, and to consider the likely impact of disasters on women's reproductive health and family planning program.
What am I being invited to do?
The themes of KIIs include recording information about the extreme climate events that have occurred in the 10 to 20 years; and the seasonal patterns and likely time of the year disasters mostly happen. Your participation will be of your own free will. The KIIs will be audio–recorded using a digital recording device so that we do not lose any of the information provided. If you agree to participate, you will be asked to sign in a consent form.
How much time will my involvement in the project take?
Each KII will last long around 45 minutes.
Are there any risks associated with participating in this project?
We do not anticipate any risk associated with your participation in the research project. Your privacy will be maintained, and you have your own free will to choose to not answer any sensitive questions, such as those about loss of life or severe damage in the locality. Moreover, you can withdraw your participation at any time during the KII if you wish.
What are the potential benefits of the research project?
While this research may be of no direct benefit to you, the information you provide helps us to understand the vulnerability of the areas and households in rural Bangladesh. This information, once published, may be of help for local government and non–governmental organizations (NGOs) in future to support Bangladeshi villagers during and after a natural disaster.
Can I withdraw from the project?
Participation in this project is completely voluntary. Upon your interest to participate, you also can withdraw your participation at any time. There will be no effects on you if you choose to withdraw from the KII or to participate in the study and the information you have provided will be excluded from the research at your request.

What will happen to my information?
Confidentiality and privacy: All identifying information will be removed from the information you provide and it will remain non–identifiable in the published format. No names of any respondents will be given in the PhD thesis and any other publications. Therefore, the utmost care will be taken to ensure that no personally identifying details are revealed after the information is collected.
Storage: The information you provide will be stored on a computer with a password and in a locked office at the University of Adelaide for at least five years following the date of thesis submission. Only the researchers on the project have access to the information.
Publishing: The research findings will be published as a PhD thesis, academic journal articles and conference papers where no names of any respondents will be identifiable. Non–identifiable socio–demographic factors such as age, gender, and occupation may be provided to validate the quotations of participants but names of participants will not be used.
Sharing: The information collected as part of this project will not be shared with others except researchers and will not be used for any future research project. The transcripts and summary of the results will be provided to participants upon request. However, no raw data or other information about participants will be shared with other participants.
Your information will only be used as described in this participant information sheet and it will only be disclosed according to the consent provided, except as required by law.
Who do I contact if I have questions about the project?
Please, if you have any questions or comments about this research project, feel free to contact
A/Prof Yan Tan, Room G 32, Napier, School of Social Sciences, North Terrace, the University of Adelaide. South Australia 5005, by telephone +614 83133976 or by email at yan.tan@adelaide.edu.au
You can also contact
Dr Dianne Marie Rudd, Room G 34, Napier, School of Social Sciences, North Terrace, the University of Adelaide. South Australia 5005, by telephone +614 83134109 or by email at dianne.rudd@adelaide.edu.au.

And

Khandaker Jafor Ahmed, Room G 38, Napier, School of Social Sciences, North Terrace, the University of Adelaide. South Australia 5005, by telephone +614 91174392 or by email at khandaker.ahmed@adelaide.edu.au

What if I have a complaint or any concerns?
The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number **H–2019–077**). This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research 2007 (updated 2018). If you have questions or problems associated with the practical aspects of your participation in the project or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator.

If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on:

Phone: +61 8 8313 6028
Email: hrec@adelaide.edu.au
Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, Adelaide SA 5000
Any complaint or concern will be treated in confidence and thoroughly investigated. You will be informed of the outcome.

If I want to participate, what do I do?
If you would like to participate in this focus group, please contact Khandaker Jafor Ahmed in person or by phone (+88 01771 85 29 83).
If you want to participate, you will need to sign a consent form to agree to participate in the research before the KII begins. The questions for the KII will be provided to you before the day so that you have time to consider the information you may share.

We thank you for your participation in this important research project.

Yours sincerely,

A/Prof Yan Tan: Principal Supervisor and Investigator
Dr Dianne Marie Rudd: Co–Supervisor
Khandaker Jafor Ahmed: PhD Candidate

PARTICIPANT INFORMATION SHEET FOR HOUSEHOLD SURVEY

PROJECT TITLE: The Impacts of Natural Disasters on Fertility Intentions and Outcomes in Bangladesh

HUMAN RESEARCH ETHICS COMMITTEE APPROVAL NUMBER: H–2019–077

PRINCIPAL INVESTIGATOR: A/Prof Yan Tan
STUDENT RESEARCHER: Khandaker Jafor Ahmed
STUDENT'S DEGREE: Doctor of Philosophy (PhD)

Dear Participant,
You are invited to participate in the research project described below.

What is the project about?
This research aims to investigate the impacts of loss and damage to households and villages, including injury and child mortality, from extreme climate events in rural villages in Bangladesh. The study will examine the impacts of these events on women's decisions to want to have more children or not.
Who is undertaking the project?
Khandaker Jafor Ahmed is conducting this project. This research will form the basis for the degree of Doctor of Philosophy (PhD) at the University of Adelaide in South Australia under the supervision of A/Prof Yan Tan and Dr Dianne Marie Rudd.
Why am I being invited to participate?
You are being invited to complete this household survey as you are an inhabitant of the village selected for this study and you, and your household, may have experienced several extreme climate events while living in the village. We want to know more about how these extreme climate events may have affected your family structure, your house and income or livelihood, and any future family intentions you may have. You are considered the best person to be able to tell us about the birth histories of all children you have ever born and any decisions or thoughts about future children.
What am I being invited to do?
A female research assistant will come to fill out a household survey at a time and place that is convenient for you. This household survey contains questions to help us know your experiences of past extreme climate eventss and perceptions of any future extreme climate events, such as floods or cyclones. We want to know what happened with your family and household in the last natural disaster, to know about your family's details, including your birth histories. You are being invited in this household survey to share the information as mentioned above; your participation is at your own free will. If you agree to participate, you will be asked to sign a consent form prior to the start of the survey. You will also be invited to participate in an in–depth interview as part of a later phase of this project, but you are not obligated to take part in the later phase of the research.
How much time will my involvement in the project take?
The survey will take around 60 minutes to complete.
Are there any risks associated with participating in this project?
While we do not anticipate any risk associated with your participation in the research project there are some sensitive questions in the survey related to possible loss of a child and the impacts to your home and family from past extreme climate events. We understand that sharing this information may be distressing for you. You can skip any of the questions that you find distressing during the survey. Moreover, you can withdraw participation at any time during the survey if you wish. In the case of any distress during the survey, details of a contact from the local family planning worker will be provided, who will be able to provide you with counselling services. We can assure you that any information you share will remain confidential and not be shared with anybody other than the researchers on this project. Your privacy will be maintained at all times and know identifying information will be used.
What are the potential benefits of the research project?
While there will be no direct benefits to you from participating in this project the information you provide will help us to understand the vulnerability and impacts of extreme climate events on the socio–

economic and demographics of households in rural Bangladesh. This information, once published, may be of help to the local government, non–governmental organisations (NGOs), and family planning workers in the future to support the villagers in rural Bangladesh during and after a natural disaster.

Can I withdraw from the project?

Participation in this project is completely voluntary and is not related to any services you are currently receiving in the village. If you choose to participate, you also can withdraw your participation at any time. There will be no effects on you if you disagree and withdraw your participation and any provided information will be excluded from the research. If you deny or withdraw your participation, it will not affect any local services or benefits you receive from the family planning workers.

What will happen to my information?

Confidentiality and privacy: All identifying information will be removed from the information you provide and it will remain non–identifiable in the published format. No names of any respondents will be given in the PhD thesis and any other publications. Therefore, the utmost care will be taken to ensure that no personally identifying details are revealed after the information is collected.

Storage: The information you provide will be stored on a computer with a password and in a locked office at the University of Adelaide for at least five years following the date of thesis submission. Only the researchers on the project have access to the information.

Publishing: The research findings will be published as a PhD thesis, academic journal articles and conference papers where no names of any respondents will be identifiable. Non–identifiable socio–demographic factors such as age, gender, and occupation may be provided to validate the quotations of participants but names of participants will not be used.

Sharing: The information collected as part of this project will not be shared with others except researchers and will not be used for any future research project. The summary of the results will be provided to participants upon request. However, no raw data or other information about participants will be shared with other participants.

Your information will only be used as described in this participant information sheet and it will only be disclosed according to the consent provided, except as required by law.

Who do I contact if I have questions about the project?

Please, if you have any questions or comments about this research project, feel free to contact

A/Prof Yan Tan, Room G 32, Napier, School of Social Sciences, North Terrace, the University of Adelaide. South Australia 5005, by telephone +614 83133976 or by email at yan.tan@adelaide.edu.au.

You can also contact

Dr Dianne Marie Rudd, Room G 34, Napier, School of Social Sciences, North Terrace, the University of Adelaide. South Australia 5005, by telephone +614 83134109 or by email at dianne.rudd@adelaide.edu.au

And

Khandaker Jafor Ahmed, Room G38, Napier, School of Social Sciences, North Terrace, the University of Adelaide. South Australia 5005, by telephone +614 91174392 or by email at khandaker.ahmed@adelaide.edu.au

What if I have a complaint or any concerns?

The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number **H–2019–077**). This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research 2007 (updated 2018). If you have questions or problems associated with the practical aspects of your participation in the project or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator.

If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on:

Phone: +61 8 8313 6028
Email: hrec@adelaide.edu.au

Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, Adelaide SA 5000
Any complaint or concern will be treated in confidence and thoroughly investigated. You will be informed of the outcome.

If I want to participate, what do I do?

If you would like to participate in a household survey please contact Khandaker Jafor Ahmed in person or by phone (+88 01771 85 29 83). This person will arrange for a research assistant to visit you at a time and place that is convenient for you to undertake the survey. You may want to have a family member or friend with you during the survey.

If you want to participate, you will need to sign a consent form to agree to participate in the research before the household survey begins. The questions for the survey can be provided to you before the day so that you have time to consider the information you may share if you prefer. It should be noted that there are other activities associated with this project that you may wish to be involved in, namely an in–depth interview. If you choose to be involved in an in–depth interview your information from the survey may be linked to the interview data. Information about the interview will be given at time of the survey.

We thank you for your participation in this important research project.

Yours sincerely,

A/Prof Yan Tan: Principal Supervisor and Investigator
Dr Dianne Marie Rudd: Co–Supervisor
Khandaker Jafor Ahmed: PhD Candidate

PARTICIPANT INFORMATION SHEET FOR IN–DEPTH INTERVIEWS

PROJECT TITLE: The Impacts of Natural Disasters on Fertility Intentions and Outcomes in Bangladesh

HUMAN RESEARCH ETHICS COMMITTEE APPROVAL NUMBER: H–2019–077

PRINCIPAL INVESTIGATOR: A/Prof Yan Tan
STUDENT RESEARCHER: Khandaker Jafor Ahmed
STUDENT'S DEGREE: Doctor of Philosophy (PhD)

Dear Participant,
You are invited to participate in the research project described below.

What is the project about?
This research aims to investigate the impacts of loss and damage to households and villages, including injury and child mortality, from extreme climate events in rural villages in Bangladesh. The study will examine the impacts of these events on women's decisions to want to have more children or not.
Who is undertaking the project?
Khandaker Jafor Ahmed is conducting this project. This research will form the basis for the degree of Doctor of Philosophy (PhD) at the University of Adelaide in South Australia under the supervision of A/Prof Yan Tan and Dr Dianne Marie Rudd.
Why am I being invited to participate?
You are being invited to undertake this in–depth interview as you expressed your willingness to take part during the household survey. You have been selected for an in–depth interview as we found your information during the household survey very helpful for our research project.
What am I being invited to do?
The in–depth interview is a semi–structured discussion, where some of the themes from the household survey will be explored further. This includes your perceptions and experiences of extreme climate events, including any experiences of child mortality. You will also be asked about your intentions and reasons to have, or not have, more children, and the birth histories of your other children. Along with the set questions you may be asked follow–up questions and may be asked to expand on information from the household survey. If you find any of the questions distressing or challenging you have full freedom not to answer. The interview will be audio–recorded so that we do not lose any information. You will also be asked to sign another consent form before participating in the interview.
How much time will my involvement in the project take?
An in–depth interview will last long around 60 minutes.
Are there any risks associated with participating in this project?
While we do not anticipate any risk associated with your participation in the interview stage of this research project, as with the household survey, there are some sensitive questions in the interview related to possible loss of a child and the impacts to your home and family from past extreme climate events. We understand that sharing this information may be distressing for you. You can skip any of the questions that you find distressing during the interview. Moreover, you can withdraw participation at any time during the interview if you wish. In the case of any distress during the interview, details of a contact from the local family planning worker will be provided, who will be able to provide you with counselling services. We can assure you that any information you share will remain confidential and not be shared with anybody other than the researchers on this project. Your privacy will be maintained at all times and know identifying information will be used.
What are the potential benefits of the research project?
While there will be no direct benefits to you from participating in this project the information you provide will help us to understand the vulnerability and impacts of extreme climate eventss on the socio–economic and demographics of households in rural Bangladesh. This information, once published, may be of help to the local government, non–governmental organisations (NGOs), and

family planning workers in the future to support the villagers in rural Bangladesh during and after a natural disaster.

Can I withdraw from the project?

Participation in this project is completely voluntary and is not related to any services you are currently receiving in the village. If you choose to participate, you also can withdraw your participation at any time. There will be no effects on you if you disagree and withdraw your participation and any provided information will be excluded from the research. If you deny or withdraw your participation, it will not affect any local services or benefits you receive from the family planning workers.

What will happen to my information?

Confidentiality and privacy: All identifying information will be removed from the information you provide and it will remain non–identifiable in the published format. No names of any respondents will be given in the PhD thesis and any other publications. Therefore, the utmost care will be taken to ensure that no personally identifying details are revealed after the information is collected.

Storage: The information you provide will be stored on a computer with a password and in a locked office at the University of Adelaide for at least five years following the date of thesis submission. Only the researchers on the project have access to the information.

Publishing: The research findings will be published as a PhD thesis, academic journal articles and conference papers where no names of any respondents will be identifiable. Non–identifiable socio–demographic factors such as age, gender, and occupation may be provided to validate the quotations of participants but names of participants will not be used.

Sharing: The information collected as part of this project will not be shared with others except researchers and will not be used for any future research project. The summary of the results will be provided to participants upon request. However, no raw data or other information about participants will be shared with other participants.

Your information will only be used as described in this participant information sheet and it will only be disclosed according to the consent provided, except as required by law.

Who do I contact if I have questions about the project?

Please, if you have any questions or comments about this research project, feel free to contact

A/Prof Yan Tan, Room G 32, Napier, School of Social Sciences, North Terrace, the University of Adelaide. South Australia 5005, by telephone +61 883133976 or by email at yan.tan@adelaide.edu.au

You can also contact

Dr Dianne Marie Rudd, Room G 34, Napier, School of Social Sciences, North Terrace, the University of Adelaide. South Australia 5005, by telephone +614 83134109 or by email at dianne.rudd@adelaide.edu.au

And

Khandaker Jafor Ahmed, Room G 38, Napier, School of Social Sciences, North Terrace, the University of Adelaide. South Australia 5005, by telephone +614 91174392 or by email at khandaker.ahmed@adelaide.edu.au.

What if I have a complaint or any concerns?

The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number **H–2019–077**). This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research 2007 (updated 2018). If you have questions or problems associated with the practical aspects of your participation in the project or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator.

If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on:

Phone: +61 8 8313 6028
Email: hrec@adelaide.edu.au
Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, Adelaide SA 5000

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

If I want to participate, what do I do?
If you want to participate, you will need to contact the researcher or the person who conducted your household survey to arrange a time and place that is convenient for you. You will also need to sign a consent form to agree to participate prior to starting the interview. The questions for the interview will be provided to you before the day so that you have time to consider the information you may share.
We thank you for your participation in this important research project.

Yours sincerely,

A/Prof Yan Tan: Principal Supervisor and Investigator
Dr Dianne Marie Rudd: Co–Supervisor
Khandaker Jafor Ahmed: PhD Candidate

Appendix K. Informed consent (focus group discussions, key-informant interviews, household surveys, and in-depth interviews)

Human Research Ethics Committee (HREC)

CONSENT FORM FOR FOCUS GROUP DISCUSSIONS

1. I have read the attached Participant Information Sheet and agree to take part in the following research project:

Title:	The Impacts of Natural Disasters on Fertility Intentions and Outcomes in Bangladesh
Ethics Approval Number:	**H–2019–077**

2. I have had the project, as far as it affects me, and the potential risks and burdens thoroughly explained to my satisfaction by the research worker. I have had the opportunity to ask any questions I may have about the project and my participation. My consent is given freely.
3. I have been allowed to have a member of my family or a friend present while the project was explained to me.
4. Although I understand the purpose of the research project, it has also been explained that my involvement may not be of any benefit to me.
5. I agree to participate in the activities outlined in the participant information sheet.
6. I agree to be:
   Audio recorded ☐ Yes ☐ No
7. I have been informed that the information gained in the project may be published in a PhD thesis/book/journal article/conference presentation.
8. I have been informed that in the published materials, I will not be identified and my personal results will not be divulged.
9. I am aware that I should keep a copy of this Consent Form when completed, and the attached Information Sheet.

Participant to complete:

Name: ________________________ Signature: _____________________________

Date: __________________________

Researcher/Witness to complete:

I have described the nature of the research to

____

(print name of participant)

and in my opinion, she/he understood the explanation.

Signature: ______________________ Position: ________________________________

Date:

Human Research Ethics Committee (HREC)

CONSENT FORM FOR KEY INFORMANT INTERVIEWS (KIIs)

1. I have read the attached Information Sheet and agree to take part in the following research project:

Title:	The Impacts of Natural Disasters on Fertility Intentions and Outcomes in Bangladesh
Ethics Approval Number:	**H–2019–077**

2. I have had the project, so far as it affects me, and the potential risks and burdens thoroughly explained to my satisfaction by the research worker. I have had the opportunity to ask any questions I may have about the project and my participation. My consent is given freely.
3. I have been allowed to have a member of my family or a friend present while the project was explained to me.
4. Although I understand the purpose of the research project, it has also been explained that my involvement may not be of any benefit to me.
5. I agree to participate in the activities outlined in the participant information sheet.
6. I agree to be:

   Audio recorded ☐ Yes ☐ No
7. I have been informed that the information gained in the project may be published in a PhD thesis/book/journal article/conference presentation.
8. I have been informed that in the published materials, I will not be identified and my personal results will not be divulged.
9. I am aware that I should keep a copy of this Consent Form when completed, and the attached Information Sheet.

Participant to complete:

Name: ________________________ Signature: __________________________

Date: __________________________

Researcher/Witness to complete:

I have described the nature of the research to

____

(print name of participant)

moreover, in my opinion, she/he understood the explanation.

Signature: ______________________ Position:_________________________

Date:

Human Research Ethics Committee (HREC)

CONSENT FORM FOR HOUSEHOLD SURVEY

1. I have read the attached Information Sheet and agree to take part in the following research project:

Title:	The Impacts of Natural Disasters on Fertility Intentions and Outcomes in Bangladesh
Ethics Approval Number:	**H–2019–077**

2. I have had the project, so far as it affects me, and the potential risks and burdens thoroughly explained to my satisfaction by the research worker. I have had the opportunity to ask any questions I may have about the project and my participation. My consent is given freely.
3. I have been given the opportunity to have a member of my family or a friend present while the project was explained to me.
4. Although I understand the purpose of the research project, it has also been explained that my involvement may not be of any benefit to me.
5. I agree to participate in the activities outlined in the participant information sheet.
6. I agree to be:

   Audio recorded ☐ Yes ☐ No
7. I have been informed that the information gained in the project may be published in a PhD thesis/book/journal article/conference presentation.
8. I have been informed that in the published materials I will not be identified and my results will not be divulged.
9. I am aware that I should keep a copy of this Consent Form when completed, and the attached Information Sheet.

Participant to complete:

Name: ________________________ Signature: _____________________________

Date: __________________________

Researcher/Witness to complete:

I have described the nature of the research to

____

(print name of participant)

and in my opinion she/he understood the explanation.

Signature: ______________________ Position:______________________________

Date: __________________________

Human Research Ethics Committee (HREC)

CONSENT FORM FOR IN–DEPTH INTERVIEWS

1. I have read the attached Information Sheet and agree to take part in the following research project:

Title:	The Impacts of Natural Disasters on Fertility Intentions and Outcomes in Bangladesh
Ethics Approval Number:	**H–2019–077**

2. I have had the project, so far as it affects me, and the potential risks and burdens thoroughly explained to my satisfaction by the research worker. I have had the opportunity to ask any questions I may have about the project and my participation. My consent is given freely.
3. I have been allowed to have a member of my family or a friend present while the project was explained to me.
4. Although I understand the purpose of the research project, it has also been explained that my involvement may not be of any benefit to me.
5. I agree to participate in the activities outlined in the participant information sheet.
6. I agree to be:

   Audio recorded ☐ Yes ☐ No
7. I have been informed that the information gained in the project may be published in a PhD thesis/book/journal article/conference presentation.
8. I have been informed that in the published materials, I will not be identified and my personal results will not be divulged.
9. I am aware that I should keep a copy of this Consent Form when completed, and the attached Information Sheet.

Participant to complete:

Name: ________________________ Signature: __________________________

Date: __________________________

Researcher/Witness to complete:

I have described the nature of the research to

____

(print name of participant)

moreover, in my opinion, she/he understood the explanation.

Signature: ______________________ Position:_________________________

Date:

Appendix L. List of participants in focus groups (with males) and in–depth interviews (with married women) for which quotations have been used

- **Focus group discussions (Males)**

Participant serial	Occupation	Age (years)	Villages affected by	Date of discussions	Participated in the focus group number
1	High school teacher	40	Floods	27/09/2019	FGD 3
2	Fisherman	25	Cyclones	27/08/2019	FGD 1
3	Small entrepreneur	42	Cyclones	27/08/2019	FGD 1
4	Farmer	45	Cyclones	27/08/2019	FGD 1
5	Fisherman	25	Floods	20/09/2019	FGD 1
6	Primary school teacher	34	Floods	20/09/2019	FGD 1, 5
7	Farmer	37	Floods	20/09/2019	FGD 1, 5
8	NGO official	30	Cyclones	04/09/2019	FGD 2
9	Farmer	42	Floods	24/09/2019	FGD 2
10	Fisherman	36	Cyclones	04/09/2019	FGD 2
11	Day labour	43	Cyclones	04/09/2019	FGD 2
12	Farmer	38	Cyclones	04/09/2019	FGD 2
13	Farmer	32	Floods	24/09/2019	FGD 2
14	Fisherman	46	Floods	24/09/2019	FGD 2
15	Day labour	43	Floods	24/09/2019	FGD 2
16	Fisherman	45	Cyclones	12/12/2019	FGD 4
17	High school teacher	45	Cyclones	12/12/2019	FGD 4, 5
18	Entrepreneur	36	Floods	04/10/2019	FGD 4
19	Farmer	40	Cyclones	12/12/2019	FGD 4
20	NGO official	33	Cyclones	12/12/2019	FGD 4

- **In–depth interviews (Females)**

Participant serial	Age (years)	Number of children	Number of sons	Number of daughters	If wanted another child	If did not want another child	Villages affected by	Date of interviews
1	32	4	0	4		√	Cyclones	07/09/2019
2	35	5	4	1		√	Floods	14/10/2019
3	30	3	1	2		√	Floods	14/10/2019
4	30	3	0	3	√		Cyclones	10/09/2019
5	28	2	1	1		√	Floods	13/10/2019
6	24	1	0	1	√		Cyclones	10/09/2019
7	26	2	1	1	√		Cyclones	07/09/2019
8	23	1	0	1	√		Floods	14/10/2019

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