

Chapter 18

Impacts of Climate-Induced Events on the Season-Based Agricultural Cropping Pattern and Crop Production in the Southwestern Coastal Region of Bangladesh



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Abstract Agricultural cropping pattern and crop production in the Southwestern coastal region of Bangladesh is affected severely by climate-induced events and climatic variability. This study shows the impacts of climatic-induced events (e.g., cyclone *Sidr* and *Aila*) on agricultural cropping patterns and crop production in two disaster-prone Southwestern coastal districts (i.e., *Khulna* and *Satkhira*) in Bangladesh. For analyzing the trend of climatic variability (e.g., temperature, rainfall, and relative humidity), 35 years (1980–2014) of climatic data were used. This study shows that the agricultural crop production in the selected Southern coastal region of the country had declined significantly when the two major cyclones (i.e., *Sidr* and *Aila*) approached in 2007 and 2009, respectively. A correlation analysis has been performed between annual average crop production and annual average climatic data to identify the influence of climatic variability on crop production.

Keywords Climate · Crop production · Climatic variability · Bangladesh

Introduction

In South Asian countries, the impacts of climate change on various sectors, including freshwater, rainfall, temperature, soil moisture, etc., have severely hindered crop yield (Arnell et al. 2016). In Bangladesh, the impact of climate change on agricultural crop production is a growing concern, especially for long-term agricultural

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development. As the vast majority of the country's population relies on agriculture, crop production is highly vulnerable to changes in the climatic system in Bangladesh (Amin et al. 2015). Different studies (e.g., Islam et al. 2020; Chen et al. 2016; Amin et al. 2015; Zakaria et al. 2014; Rimi et al. 2009; Rokonuzzaman et al. 2018; Hossain et al. 2019; Sikder and Xiaoying 2014) reported that agricultural cropping patterns and crop productivity could be severely affected due to the changing pattern of seasonal climatic factors, including temperature, rainfall, humidity, and day length. Additionally, different climate-induced events, such as cyclones, floods, storm surges, droughts, sea level rise, coastal flooding, etc., profoundly impact agricultural cropping patterns and production in Bangladesh (Islam et al. 2020). Agriculture is the backbone of Bangladesh, which significantly influences the country's food security. Apart from food security, this sector has considerable impacts on the country's GDP and employment generation (GED 2021). Currently, this sector generates 12.65% of the country's GDP and employs around 50% of the population (World Bank 2021; Imdad 2021). Although the government of Bangladesh envisioned achieving the universal food security target by 2021, the most pressing concern is increased crop production demand for the rapidly growing population and the climate change impacts on the agricultural sector (GED 2021). It is evident that Bangladesh is one of the highly vulnerable countries worldwide in terms of climate change impacts due to its geographic location between the Himalayas and the Bay of Bengal, making it vulnerable to natural events (Ahmed 2006). The agricultural sector is the most vulnerable and affected in Bangladesh due to climate change (Islam et al. 2015).

In the coastal regions of Bangladesh, the agricultural sector is highly susceptible to climate change impacts, where a significant portion of the population relies on it for livelihood (Islam et al. 2020). Out of 2.85 million hectares of the coastal and offshore regions in Bangladesh, approximately 0.83 million hectares are arable lands, covering more than 30% of the total cultivable lands of the country (Petersen and Shireen 2001). In Bangladesh, the Southern coastal region is severely affected by climate change, notably agricultural crop production (Islam et al. 2020). For instance, two devastating cyclones (i.e., *Sidr* and *Aila*) approached in 2007 and 2009, respectively, severely damaged agricultural production in the Southern region of the country (BBS 2009). In Bangladesh, the impacts of climate change on the agricultural sector have drawn much attention in the recent decade. Some studies were conducted on this issue, primarily focusing on the climate change vulnerability and adaptation practices (Rokonuzzaman et al. 2018; Sikder and Xiaoying 2014; Abedin and Shaw 2013; Huq et al. 2015). Rimi et al. (2009) and Hossain et al. (2019) conducted a study to investigate the impacts of changing climatic variables on rice production in the Southern region of Bangladesh. Islam et al. (2020) studied the influence of climate-induced events and climatic variability on cropping patterns and crop production in the *Satkhira* region, Bangladesh. In this study, we investigate the existing agricultural cropping patterns and status of crop production in two disaster-prone Southwestern coastal districts in Bangladesh (i.e., *Khulna* and

Satkhira), the influence of climatic variability and major climate-induced events (e.g., *Sidr* and *Aila*) on annual crop production, and the correlation between annual crop production and different climatic parameters in the study areas.

Methodology

Study Area

This study was conducted in different Upazilas (i.e., *Dacope*, *Koyra*, *Paikgachha*, *Batiaghata*, *Dumuria*, *Assasuni*, and *Kalaroa*) of the *Khulna* and *Satkhira* districts located in the Southwestern coastal part of Bangladesh (Fig. 18.1). The annual average temperature and rainfall of this region range from 12.5 to 35.5 °C and 1710 to 2500 mm, respectively (Islam et al. 2020; Hossain et al. 2019). This study considered these two Southwestern coastal districts of Bangladesh to provide an overview of the impacts of climatic variability and climate-induced events on agricultural cropping patterns and annual crop production. This study selected this region as the country's Southwestern coastal part is more susceptible to climate-induced events (e.g., cyclones, saltwater intrusion due to coastal flooding or storm surge, etc.).

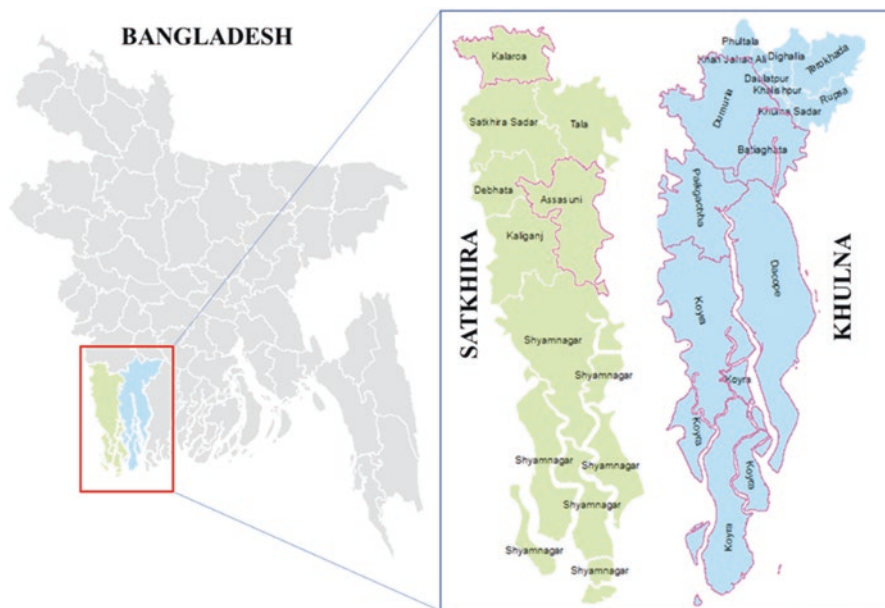


Fig. 18.1 Map of *Khulna* and *Satkhira* districts showing the selected study

Data Collection

This study was mainly conducted based on the secondary data gathered from different local and national sources. Agricultural land area, cropping pattern, and crop production data (e.g., *Aus*, *Aman*, and *Boro* rice) for different seasons (i.e., *Kharif-I*, *Kharif-II*, and *Robi*) for the selected study areas had been collected from the local Agriculture Extension Office (AEO). To analyze this region's climatic variability, 35 years (1980–2014) of climatic data (temperature, humidity, and rainfall) were collected from the Bangladesh Meteorological Department (BMD). However, primary data were also collected from the farmers, local communities, and relevant professionals for obtaining in-depth information regarding various issues relevant to the study (e.g., existing cropping patterns, the status of crop production, concept on climate change, climate-induced events and their frequency in the study areas, and adaptation practices). Primary data were collected through the questionnaire survey, key informant interview (KII) with the government officials (i.e., Upazila Agriculture Extension Officers) and NGOs (e.g., BRAC and Muslim Aid, Winrock International, Prodipon, Rupantor), and through the focus group discussion (FGD) with the farmers of selected Upazilas and local communities. A total of 10 KII had been conducted with the officials of government organizations and NGOs. For the questionnaire survey, 200 respondents (100 from each district) were selected randomly. Besides, a total of eight FGD sessions were conducted between March and October 2015.

Data Analysis

Microsoft Excel and SPSS-20 software were used for data calculation and data analysis. Based on the availability of annual crop production data in three different seasons (i.e., *Kharif-I*, *Kharif-II*, and *Robi* season) and climatic data (temperature, rainfall, and humidity) for the selected study areas, Pearson correlation has been performed among annual average crop production and annual average climatic variability.

Results and Discussion

Climate Change and Its Impacts on the Agricultural Sector in Bangladesh: An Overview

Bangladesh is one of the world's most vulnerable countries to climate change. Located as an interface of the Himalayas and the Bay of Bengal, the country is highly susceptible to natural disasters (Hossain et al. 2018; Huq and Shoaib 2013).

Climate change has increased the severity and frequency of different events, including cyclones, salinity intrusion, droughts, erratic rainfall, high temperatures, flash floods, etc. (Aggarwal et al. 2013; Huq et al. 2015; Rokonuzzaman et al. 2018). As a heavily populated deltaic region, Bangladesh is experiencing the early effects of climate change due to its geographical location, height above sea level, and floodplains (Ahmad 2019; Islam et al. 2020). The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) mentioned that Bangladesh has already experienced these devastating impacts resulting from climate change (Hijioka et al. 2014). These climate-induced events would be more frequent and extreme in the future and would severely impact various sectors of the country, including agriculture, fisheries, livestock, health, and human livelihood (Ahmad 2019). Sikder and Xiaoying (2014) reported that in the agricultural sector, crop agriculture is highly vulnerable to climate change impacts in Bangladesh.

In Bangladesh, the coastal area covers an area of 47,201 km², with more than 37 million people relying on it (Dasgupta et al. 2015). The coastal regions of Bangladesh, mainly the Western and Central coastal regions, are highly vulnerable to climate change impacts (Karim and Mimura 2008). The Western coastal part of the country is surrounded by the world's largest mangrove forest (i.e., the Sundarbans). However, it is a low-lying area subjected to frequent coastal flooding caused by cyclones or storm surges (Ahmad 2019), which have significant impacts on the agricultural sector (including crop agriculture) (Islam et al. 2020). As the population in the coastal region could reach 60 million by 2050 (Dasgupta et al. 2015), the decline in agricultural yield due to climate change could severely impact food security for the growing population (Ismail 2016). Shahid (2010) reported that climate change is anticipated to result in a constant increase in temperature and a change in rainfall pattern, resulting in substantial impacts on agriculture. Table 18.1 shows the reported or possible impacts of climate-induced events in Bangladesh.

Cropping Seasons and Major Cultivated Crop Species

The climate of Bangladesh ranges from subtropical to tropical, which favors the cultivation of a large variety of crops (both rice and non-rice) in different seasons. Generally, crop cultivation has been performed in three different seasons across the country. These include *Kharif-I* (extended from mid-March to mid-July), *Kharif-II* (extended from mid-July to mid-November), and *Robi* (extended from mid-November to mid-March). The Southern region of the country is characterized by the tropical climate, where different crops have been cultivated in these seasons under two different environmental conditions (Table 18.2). The study identified that in the *Kharif-I* season, the dominant crop species is the *Aus* rice. In contrast, it has been observed that T. *Aman* (transplanted *Aman*) is the major crop species during the *Kharif-II* season in the Southern region. In *Robi* (dry season), *Boro* rice is the main cultivated rice species, along with other non-rice crops (Table 18.2).

Table 18.1 Impacts of Climate-Induced Events in Bangladesh

Events	Reported/possible impacts or changes	References
Sea level rise, storm surges, and coastal or riverine flooding	Inundation of crops and increased soil salinity, resulting in substantial loss of agricultural productivity More than 7% reduction in annual rice production during 2005–2050	Sikder and Xiaoying (2014) and Yu et al. (2010)
Cyclones	The tropical cyclone <i>Sidr</i> damaged 698,391 tons of <i>Aman</i> rice in 2007–2008 in the Southern coastal region The tropical cyclone <i>Sidr</i> damaged 1446 acres of <i>Boro</i> seedbed in 2007–2008 in the Southern coastal region Significant changes in annual rice (<i>Aus</i> , <i>Aman</i> , and <i>Boro</i>) production after 2007–2008 due to cyclone <i>Sidr</i>	Haque et al. (2016) and Islam et al. (2020)
Temperature	1.9 °C increase in temperature by 2030 Rising temperature caused by climate change resulting in lower crop production Substantial decline in cereal (rice and wheat) production, resulting from increased temperature <i>Boro</i> rice and wheat would drop by 55–62% and 61%, respectively, by 2050 due to increased temperature	IPCC (2007), Sikder and Xiaoying (2014), Stern (2006) and Mondal (2010)
Rainfall	5–6% increase in rainfall by 2030 Changes in rainfall could result in reduced crop yields in the country Substantial decline in cereal (rice and wheat) production, resulting from erratic rainfall	IPCC (2007), Sikder and Xiaoying (2014) and CDMP II (2013)

Table 18.2 Crop cultivation in different environmental conditions in the Southern coastal region

Conditions	Robi	Kharif-I	Kharif-II
Rainfed condition	Wheat/potato/pulses/oil seeds/sugarcane	<i>Boro</i> (local), <i>Aus</i>	Fallow
Irrigated condition	Wheat/ <i>Boro</i> /potato/winter vegetables	Fallow/ <i>T. Aus</i>	<i>T. Aman</i> /fallow

Notes: FGD and KII conducted in 2015. *T. Aus* Transplanted *Aus*, *T. Aman* Transplanted *Aman*

Status of Cropping Patterns in the Southwestern Coastal Region in Bangladesh

Cropping patterns are yearly sequences of crop production on a particular area of land (Alam 1994). In different regions of the country, a wide range of crops are grown under various cropping patterns, which vary from one location to the next.

Agricultural cropping patterns in Bangladesh and variation in crop production are heavily influenced by several factors, including climate, meteorological conditions (e.g., rainfall, temperature range), soil moisture, soil types, irrigation facilities, and availability of cultivable land (Islam et al. 2020; Rashid et al. 2017; Pande et al. 2021; Elbeltagi et al. 2022). However, in the coastal districts of Bangladesh, agricultural land usage is particularly low. For instance, in 2007–2008, the country’s average cropping intensity was 179%, whereas in the Southern region, it was much lower (ranging from 128% to 147%) (BBS 2014). The study identified different cropping patterns (both rice and non-rice) that have been practiced recently in the study areas (Tables 18.3 and 18.4).

In Bangladesh, most of the regions (including the Southern coastal region) are covered by rice-based cropping patterns, with the dominance of three main rice varieties (i.e., *Aus*, *Aman*, and *Boro*) (Huq and Shoaib 2013). This study identified that the existing cropping patterns in the selected Southwestern coastal region consist of “two-crop combinations” and “three-crop combinations” (Tables 18.3 and 18.4). Islam et al. (2020) also reported similar cropping patterns for the *Satkhira* region. Rashid et al. (2017) reported that a significant portion of land area (i.e., 63%) in the *Khulna* region is covered by rice-based cropping patterns. This study shows that in *Khulna*, “Fallow land-Fallow land-T. aman” is the dominant cropping pattern, covering more than 44% of the area. “Boro-Fallow-T. aman” and “Boro-Fallow land-Ropa aman” also cover a considerable portion (i.e., 29.5% and ~15%, respectively). However, the proportion of other cropping patterns ranged from 0.2% to ~7%, as presented in Table 18.3. In *Satkhira*, the dominant cropping pattern is identified as “Boro-Fallow land-Ropa aman,” covering more than 60% of the land, followed by “Boro-Aus-Ropa aman” (26.5%) and others (Table 18.3).

Apart from the existing cropping pattern of wide rice varieties, the study identified some major non-rice cropping patterns commonly practiced in the study areas

Table 18.3 Existing cropping pattern (rice) in the study area

Sl.	Cropping pattern (rice)	Land under cropping pattern (hec.) ^a	Percentage (%)
<i>Khulna</i>			
1.	Fallow land-Fallow land-T. aman	23,732	44.17
2.	Boro-Fallow-T. aman	15,818	29.44
3.	Boro-Fallow land-Ropa aman	8008	14.91
4.	Boro-Aus-Ropa aman	3522	6.56
5.	Boro-Fallow-Fallow	1789	3.33
6.	Boro-Aus-T. aman	452	0.84
7.	Boro-Aush-Fallow land	305	0.57
8.	Fallow-Aus-T. aman	100	0.19
<i>Satkhira</i>			
1.	Boro-Fallow land-Ropa aman	8008	60.26
2.	Boro-Aus-Ropa aman	3522	26.50
3.	Boro-Fallow land-Fallow land	1759	13.24

Notes: AEO (2014). ^aTotal land under cropping pattern in the selected study areas in 2014

Table 18.4 Existing cropping pattern (non-rice) in the study areas

Sl.	Cropping pattern (non-rice)	Land under cropping pattern (hec.) ^a	Percentage (%)
<i>Khulna</i>			
1.	Vegetables-vegetables-vegetables	4423	67.70
2.	Vegetables-jute-vegetables	1050	16.07
3.	Mustard seed-vegetables-vegetables	558	8.54
4.	Vegetables-vegetables-Fallow	175	2.68
5.	Potato-vegetables-vegetables	104	1.59
6.	Potato-vegetables-Fallow	100	1.53
7.	Spices-lentil-vegetables	61	0.93
8.	Spices-vegetables-vegetables	50	0.77
9.	Wheat-vegetables-vegetables	12	0.18
<i>Satkhira</i>			
1.	Potato-jute	2208	41.97
2.	Mustard seed (local)	1950	37.07
3.	Vegetables-vegetables-vegetables	1103	20.97

Notes: AEO (2014). ^aTotal land under cropping pattern in the selected study areas in 2014

(Table 18.4). This study shows that in *Khulna*, “vegetables-vegetables-vegetables” is the dominant cropping pattern, covering more than 68% of the land. Besides, “vegetables-jute-vegetables” and “mustard seed-vegetables-vegetables” also cover significant land under the cropping pattern (i.e., 16% and ~9%, respectively). In *Satkhira*, the dominant non-rice cropping pattern is identified as “potato-jute,” covering ~42% of the land under the cropping pattern, followed by “mustard seed (local)” and “vegetables-vegetables-vegetables” (Table 18.4).

Impacts of Climate Change on Crop Production

The agricultural cropping pattern in the Southwestern coastal region of Bangladesh is largely dominated by rice, followed by non-rice crops (Rashid et al. 2017). Hence, this study emphasized the influence of climate-induced events on rice production in the selected region of the country. Different climate-induced events are frequent in this region, resulting in substantial damage in cultivable land areas and the annual crop production. Islam et al. (2020) reported that as the land areas in this region are inundated by saline water during and post-cyclone period, soil salinity increases and, therefore, makes the land unfavorable for crop cultivation. According to the Soil Resource Development Institute (SRDI), the Southwestern part of the country, mainly *Khulna*, *Satkhira*, and *Bagerhat*, are highly vulnerable to soil salinity, which has profound impacts on crops produced in this region (SRDI 2010). Islam et al. (2015) reported that due to the salinity intrusion, different local rice varieties (e.g., *kalojira*, *najirsail*, *boran*, etc.) have already been extinct from the country’s coastal regions. According to Nishat and Mukherjee (2013), increased salinity triggered by climate-induced events reduces annual average rice production by around

0.2 million metric tons and affects the *Boro* and wheat production in the coastal saline soils. The estimated loss of rice due to the cyclones in 2007 and 2009 was nearly two million metric tons (CIAT 2017). In Bangladesh, climatic-induced events (e.g., floods, cyclones, etc.) are anticipated to become more frequent and intense and could affect the crop agriculture severely (CIAT 2017). For instance, it is projected that salinity intrusion due to climate-induced events could reduce rice and wheat production by 8% and 32%, respectively, in the coastal regions by 2050 (The Financial Express 2018).

The study reveals that in the Southwestern coastal regions, agricultural land areas and rice production vary considerably in different seasons (Fig. 18.2a, b), which is believed to be because of climate-induced events, mainly cyclone as reported by the majority of the respondents, that is, 60% (average) of the study areas. Figure 18.2a shows that in the *Kharif-II* season (extended from mid-July to mid-November), annual production of *T. Aman* rice per hectare during 2007–2008 in *Satkhira* reduced considerably (~15%) compared to 2006–2007 (i.e., 2.7 vs. 2.3 Mt/hec.). A significant reduction in *Boro* rice (~10%) in the *Robi* season (extended from mid-November to mid-March) had also been observed (i.e., 5.3 vs. 4.8 Mt/hec.). The production of *Aus* rice in the *Kharif-I* season (extended from mid-March to mid-July) reduced by 5% during the same period compared to 2006–2007 in this coastal part of the country. This reduction is due to cyclone *Sidr*, which struck Bangladesh on 15 November 2007.

In 2008–2009, the production of *Aus* rice in the *Kharif-I* reduced significantly (~50%) compared to the production rate in 2007–2008 (i.e., 18.3 vs. 9.3 Mt/hec.), which is because of the cyclone *Aila* (which struck Bangladesh on 25 May 2009). The study also identified that cyclone *Sidr* and *Aila* caused massive destruction for agricultural crop production in the *Khulna* region. For instance, in 2006–2007, the *T. Aman* high yield variety (HYV) production was 52,984 Mt, which decreased substantially (24%) in 2007–2008 (i.e., 52,984 Mt vs. 40,295.7 Mt) when cyclone *Sidr* hits at the coastal region of Bangladesh and cyclone *Aila* swept up almost all the crop fields during 2009–2010 (Fig. 18.2b).

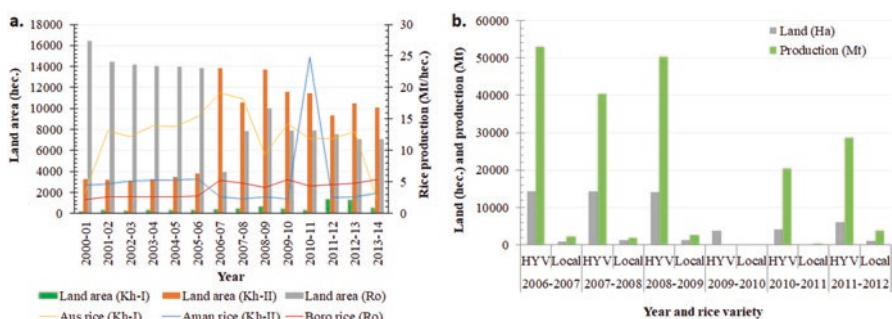


Fig. 18.2 Annual rice production with land area in different seasons: (a) *Assasuni* Upazila, *Satkhira*, and (b) production of *Aman* rice (HYV and local variety) in *Koyra* Upazila (*Khulna*). (Notes: *Kh-I* Kharif-I, *Kh-II* Kharif-II, *Ro* Robi, *HYV* high yield variety)

Trend of Variability in Climatic Parameters

The variability trends in different climatic parameters were analyzed for the *Khulna* and *Satkhira* region of Bangladesh using the average annual temperature, relative humidity, and rainfall data during the period 1980–2014 (Fig. 18.3). The study shows that in *Khulna*, the highest and lowest average annual temperatures were 26.7 °C (in 2010) and 25.2 °C (in 1981), respectively. An increasing trend (0.0254%) of average temperature was observed during this period in *Khulna*, where the coefficient of determination is 0.4908 (Fig. 18.3a). Hossain et al. (2019) reported a similar increasing temperature trend in *Khulna* during 1980–2010. In *Satkhira*, the highest and lowest average annual temperatures were recorded at 27.7 °C (in 1987) and 25.5 °C (in 1997), respectively. However, a decreasing trend (0.0371%) of average temperature was observed in this region during that period, where the coefficient of determination is 0.3666 (Fig. 18.3d). Islam et al. (2020) also reported a decreasing trend in average temperature for the *Robi* season (i.e., 0.071%) in the *Satkhira* region during 1980–2014.

The trend analysis of average annual rainfall during the study period in *Khulna* shows a slightly decreasing trend (0.7591%), where the coefficient of determination is 0.0006. The average rainfall during this period ranged from 1130 to 2594 mm, with the highest average rainfall in 2002 and the lowest in 1994 (Fig. 18.3b). Hossain et al. (2019) reported a slightly increasing trend in annual temperature during the monsoon season in the *Khulna* region. For *Satkhira*, a decreasing trend (3.3445%) was also observed during the same period, where the coefficient of determination is 0.019. The average rainfall during this period ranged from 1295 to 2195 mm, with the highest average rainfall in 1986 and the lowest in 2010 (Fig. 18.3e). Islam et al. (2020) reported a decreasing trend in average rainfall for *Robi* season (characterized by dry season) in the *Satkhira* region and a moderate trend for *Kharif-I*

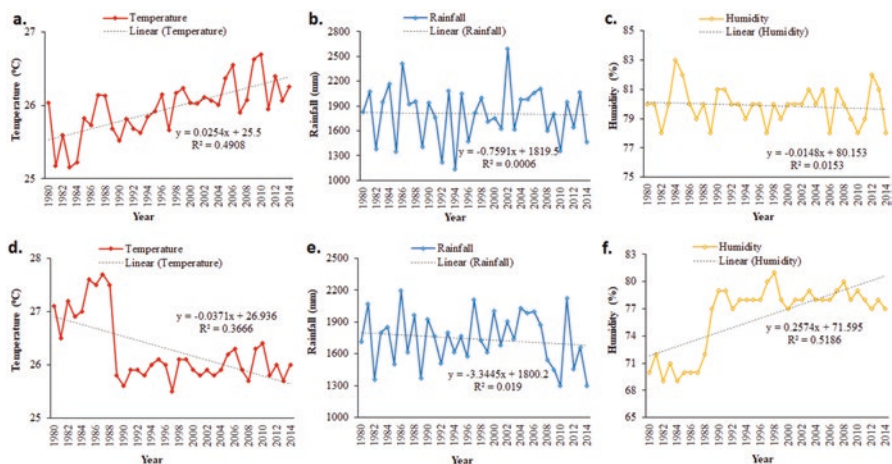


Fig. 18.3 Variability in different climatic parameters during 1980–2014 in (a–c), *Khulna* region, and (d–f), *Satkhira* region

(pre-monsoon) and *Kharif-II* (monsoon) season during 1980–2014. As variability in temperature and humidity significantly impacts the overall rainfall (Mawonike and Mandonga 2017), this erratic rainfall pattern might be occurred due to variability in temperature and relative humidity.

The average relative humidity during 1980–2014 ranged from 78% to 83% and from 69% to 81% in *Khulna* and *Satkhira*, respectively. The study identified a decreasing trend in the average relative humidity (0.0148%) in the *Khulna* region during this period, where the coefficient of determination is 0.0153 (Fig. 18.3c). However, in *Satkhira*, an increasing trend in the average relative humidity (0.2574%) was observed, where the coefficient of determination is 0.5186. A similar finding has been reported by Islam et al. (2020) for the *Satkhira* region, with an increasing trend in average relative humidity in different seasons (ranging from 0.248% to 0.431%) during 1980–2014 (Fig. 18.3f).

Correlation Between Crop Production and Climatic Parameters

Pearson correlation among annual average crop production and annual average climatic data (e.g., temperature, humidity, and rainfall) was performed in this study (Table 18.5), as we assumed that the climatic parameters influence annual crop production in the study areas. Rahman and Rahman (2019) reported that crop production in Bangladesh is largely influenced by climatic variability. It should be mentioned that the Pearson correlation has been performed based on the availability of annual crop production data. This study found a significant strong positive correlation between annual average rainfall and average crop production in *Batiaghata* Upazila in the *Khulna* region ($r = 0.961$, $p < 0.05$). A strong positive correlation between average yearly rainfall and average crop production ($r = 0.641$, $p < 0.05$) and between annual average humidity and annual average crop production ($r = 0.668$, $p < 0.05$) has been observed in *Koyra* Upazila in the *Khulna* region. However, a moderate to strong negative correlation was observed between the annual average temperature and annual average crop production (Table 18.5). For the *Satkhira* region, no significant correlation was found among annual average crop production and average annual climatic data (Table 18.5).

Local People's Perception of Climate-Induced Events, Possible Causes, and Impacts

This study used different approaches (mentioned earlier) to gather local peoples' responses regarding the climate-induced events, possible causes, and impacts in the study areas. As local people were the direct observers of different climate-induced events and the damages that occurred in the past, it was crucial to have their

Table 18.5 Pearson correlation among annual average crop production and average climatic data of *Khulna* region

	Avg. production	Avg. temperature	Avg. rainfall	Avg. humidity
<i>Dacope Upazila, Khulna (2007–2014)^a</i>				
Avg. production	1			
Avg. temperature	-0.629	1		
Avg. rainfall	0.003	-0.660	1	
Avg. humidity	0.372	-0.390	0.541	1
<i>Koyra Upazila, Khulna (2007–2012)^a</i>				
Avg. production	1			
Avg. temperature	-0.520	1		
Avg. rainfall	0.641	-0.704	1	
Avg. humidity	0.668	-0.391	0.342	1
<i>Batiaghata Upazila, Khulna (2011–2014)^a</i>				
Avg. production	1			
Avg. temperature	-0.629	1		
Avg. rainfall	0.961*	-0.757	1	
Avg. humidity	0.407	-0.366	0.32	1
<i>Assasumi Upazila, Satkhira (2000–2013)^a</i>				
Avg. production	1			
Avg. temperature	0.037	1		
Avg. rainfall	-0.222	-0.247	1	
Avg. humidity	-0.007	-0.129	-0.286	1

Notes: *Correlation is significant at the 0.05 level (two-tailed). ^aRice production data during the period used for the correlation analysis has been considered based on data availability

responses. We believe that these findings will better understand the appearance of climate-induced events and the associated impacts on the agricultural cropping system. The result (average response rate of two regions) revealed that local people now realize that climate-induced events are approaching frequently compared to the past decades with immense impacts on the agricultural sector. Most of the respondents (~63%) reported that the Southwestern coastal areas are highly vulnerable to climate-induced events and asserted the frequency of massive cyclones that occurred every 4–5-year interval, resulting in a substantial loss in crop production. A similar finding was reported by Sikder and Xiaoying (2014) and Islam et al. (2020), with a considerable loss in the agricultural sector in Southern Bangladesh due to cyclones.

Our result shows that local people in all the study areas agreed that the cropping pattern had been changed significantly in their regions, possibly due to climatic influences. For instance, a considerable proportion of the respondents (37%) reported that the cropping pattern has changed due to unreliable rainfall in the past decades and increased soil salinity (35%) due to coastal flooding and storm surges. However, some respondents mentioned that soil fertility and productivity reduction due to increased soil salinity results in changing cropping patterns. Besides, introducing high yield varieties (HYV) to cope with climate change is another reason for cropping pattern change (Fig. 18.4).

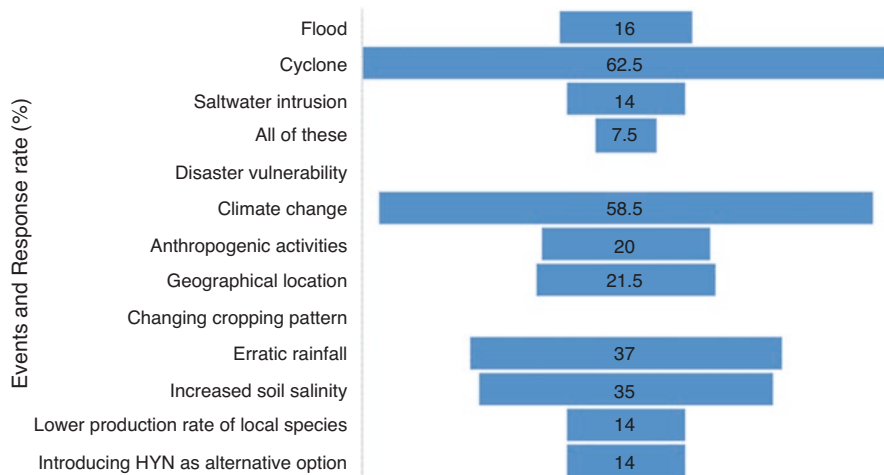


Fig. 18.4 Local peoples’ responses on climate change, its causes, and impacts

Conclusions and Recommendations

In summary, climate-induced events (e.g., cyclone *Sidr* and *Aila*) significantly impact annual crop production and change cropping patterns in Southwestern coastal Bangladesh. For instance, in the *Satkhira* region, rice production of major varieties (i.e., *T. Aman*, *Aus*, and *Boro*) in different crop growing seasons reduced by 5–15% in 2007–2008 compared to the production amount in 2006–2007, which is mainly due to effects of cyclone *Sidr*. In the *Khulna* region, the loss in crop production was even more. This study shows a 24% reduction in *T. Aman* production caused by the effects of cyclone *Sidr* during that period, and *Aus* rice production reduced by ~50% due to the impact of cyclone *Aila* in 2008–2009. The study also identified the changing trend in climatic variables (temperature, rainfall, and relative humidity) in these regions, which considerably influences annual crop production. A strong positive correlation has been observed between average annual rainfall/humidity and average crop production, while average annual temperature and average crop production were found negatively correlated. As the agricultural sector is highly susceptible to climate change, this study recommends that concerned authorities of the government should adopt proper adaptation measures in the crop agricultural production system to meet the growing demand of the country’s large population through policy reforms and effective implementation. For instance, salt-tolerant and flood-tolerant rice varieties could be practiced on a large scale in these climate-sensitive areas to cope with the climate change impacts. Besides, the government should prioritize the sustainable management of water resources for irrigation in the disaster-prone coastal regions of Bangladesh.

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