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## Abstract

Despite the substantial contribution of wetland resources to support human well-being and the threats of climate change on wetland resources, climate studies have paid less attention to wetlands in South Asia. Hence, this chapter explores the impacts and adaptation to climate change on the wetlands of southwest coastal Bangladesh using the time series (e.g. Mann–Kendall) analysis of climate data and survey data analysis for the adaptations to climate change. We have also reviewed the literature to explore whether the local development projects in wetlands integrates climate change adaptations according to the national adaptation plan. The trends of temperature in pre-monsoon, monsoon and post-monsoon are increasing over the period 1948–2012. Pre-monsoon rainfall trend is decreasing, in contrast to the increasing rainfall trends in monsoon and post-monsoon seasons. In response to the changes in climate, 78% of respondents have adopted multiple adaptation options, and 94% of respondents have adopted expensive boring methods to support agriculture. The production cost has increased three-fold in response to the changes in crop varieties to cope with climate change. The bivariate probit regression (BPR) reveals that loan taking is the determinant of climate change adaptation. Though the review of literature suggests that the impacts of climate change will be severe in the future, adaptation planning is yet not integrated into the wetlands' development plans. Some of the adaptation

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options (e.g. access to credit and innovating crop varieties with low production cost) may be included in the global development goals to strengthen climate change adaptation at global and regional scales.

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**Keywords**

Adaptation planning • Climate change • Time series • Wetlands

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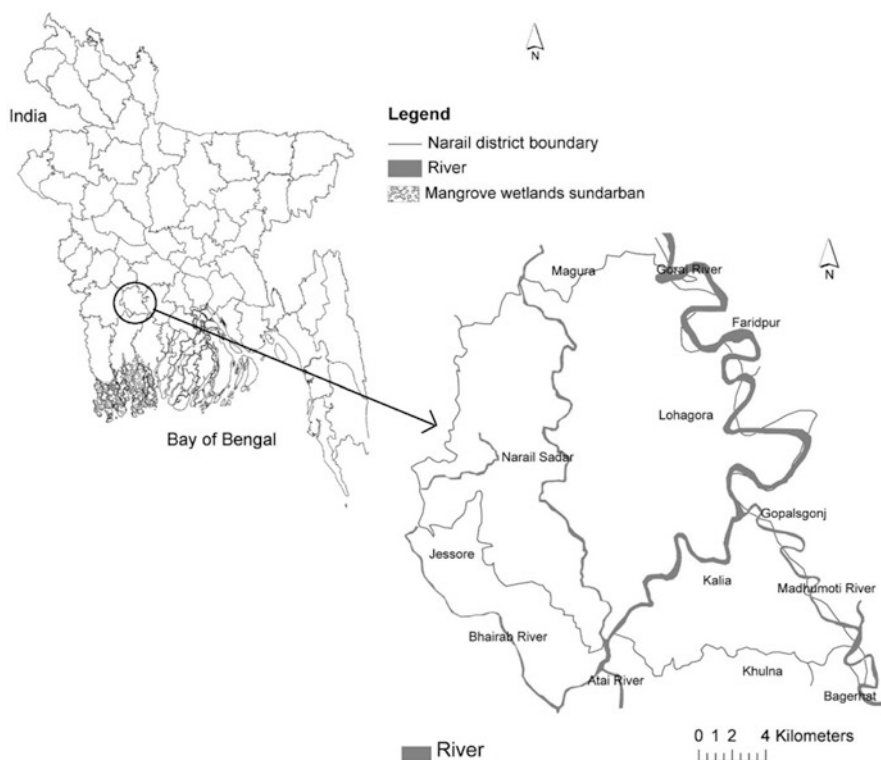
## 12.1 Introduction

Wetlands are one of the most productive biological systems, which provide enormous ecosystem services to support human wellbeing (EPA 2016). About 6% of the total global land is covered by wetlands (IPCC 1995), which store ~11,000 km<sup>3</sup> global water (Shiklomanov and Rodda 2003). The total economic value of wetlands is about 70 billion USD year<sup>-1</sup> and is the source of two-thirds of global fish consumption (IWMI 2010). However, wetland ecosystem services and biodiversity rich systems are highly threatened by climate change. Impacts of climate change on wetlands include alternation of hydrology and water quality, increase in natural hazards, decrease in water resource quantity and decrease in food production (Erwin 2009; Ramsar 2014). It has been estimated that ~1% global wetlands' stock was lost each year in the late twentieth century, and the projection shows that ~46% wetlands and more than 200 million people would be threatened by 1 m sea level rise in wetlands. About 75% South Asian wetlands would be inundated due to 1 m sea-level rise (SLR), affecting 95 million people in the region (Hoozemans et al. 1993; Nicholls 2004).

Bangladesh is known as land of rivers, and wetlands are the major (~8 million ha) land use type in the country (Khan 1993). Wetlands are the main sources of rice production (Byomkesh et al. 2009), biodiversity (~5000 flowering plants, ~1500 vertebrates) and water resources (Khan et al. 1994) in Bangladesh. It is estimated that the mangrove wetlands alone produce ~800,000 USD per year through provisioning services (e.g. forest product) and tourism industry (Uddin et al. 2013). However, this highly productive system is threatened by climate change, similar to the whole of the country, due to SLR, temperature increase, decreased water flow and other human interventions (World Bank 2000; Byomkesh et al. 2009; Hossain et al. 2013). Therefore, we need to investigate how climate change is affecting wetland resources to develop adaptation strategy for these systems. Despite the high economic contribution to human wellbeing of Bangladesh, wetlands received less attention than other natural systems such as rivers, coastal areas and forests in climate change adaptation plans. Hence, we aimed in this chapter to explore the recent trends and impacts of climate change, the adaptation processes through time series and survey data analysis and literature review. This chapter also includes a case study to provide insight in to mainstreaming climate change adaptation into the wetlands' development planning at local level.

## 12.2 Case Study: Bangladesh

We selected the wetlands in Narail District (Fig. 12.1) at the southwestern part of Bangladesh for the study. This area is highly influenced by wetlands, which are connected to the rivers (Chitra and Nabaganga) through canals and watercourses (ADB 2005). A large population (730,000) is dependent on wetlands as ~70% of people are dependent on agriculture. Although only 2% of people are fishermen, ~30–50% of people are engaged in fishing during wet season. These wetlands provide huge amount of provisioning services (e.g. crops, fish) worth ~173 million USD year<sup>-1</sup> and also accumulate 1800–3600 t CO<sub>2</sub>e km<sup>-2</sup> year<sup>-1</sup> (Hossain and Sazbo 2016). In addition, the wetlands also contribute to the cultural values of human livelihood in this area. However, half of the population of the area is below the poverty line (Saadat and Islam 2011). Besides the challenges of poverty alleviation, climate change and hydraulic engineering are making the social-ecological system of this area more vulnerable (Hossain et al. 2010; Moni and Hossain 2010). However, this region is not salinity affected compared to the other southwestern part of Bangladesh. Besides all these socioecological-economic motivations, availability of time series data and



**Fig. 12.1** Southwest coastal district of Narail, the case study area in Bangladesh

availability of relevant literatures about climate change impacts and adaptation for the wetlands of this area are the reasons to select the area as a case study to understand the impacts and adaptation in wetlands.

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### 12.3 Methods

Time series (1948–2012), temperature (monthly) and rainfall (daily) data for the nearest meteorological station (Jessore) were collected from the Bangladesh Meteorological Department (BMD). Monthly mean rainfall was calculated from the daily rainfall data. Each year was classified into four seasons: monsoon (June–July–August), post-monsoon (September–October–November), winter (December–January–February) and pre-monsoon (March–April–May). Besides analysing the trends for the period 1948–2012, we have also analysed data by dividing the total time period into three segments: 1948–1970, 1971–1990 and 1991–2012. We have applied the nonparametric Mann–Kendall test and linear regression in order to discriminate trends (increasing, decreasing or stable) in the time series data. Mann–Kendall test is applied widely to detect trends in highly variable and nonlinear systems such as temperature and precipitation (Vitale et al. 2010; Hossain et al. 2014). Similar tests were also applied to analyse the trends in the Bengali months, which coincide with the panicle and spikelet initiation time of local crops. These panicle and spikelet initiation times of local crops were collected using a farmer's perception during the focus group discussion (FGD) in the study area. We conducted five FGDs, in which 50% of the respondents were women. FGDs were also used to collect information on the production costs for the current crop varieties and the previous crop varieties. We have also surveyed 103 farmers to collect the information on their perception on climate and adaptation practices and to investigate the determinants of climate change adaptation. We used bivariate probit model (BPM) to analyse the determinants of adaptation methods to climate change in the wetlands of Bangladesh. The reason why we used this model was as we have two binary response (i.e. dummy) variables, adaptation in agriculture ( $y_1$ ) and water resources ( $y_2$ ), which vary jointly and are assumed to have correlated disturbances (Greene 2003). This method can also be used when both dependent variables are seemingly unrelated. Previously, multinomial logit models, i.e. where the discrete outcomes are more than two, have been used in climate change literature to analyse adaptation methods such as choice of crop (Hassan and Nhemachena 2008; Kurukulasuriya and Mendelsohn 2008) and livestock (Seo and Mendelsohn 2008). We have also used relevant literature to investigate future trends in climate change, impacts and possible adaptation planning in the study area. We also aimed at exploring briefly how the government is integrating national adaptation plan into the wetlands' development plans.

## 12.4 Recent Trends in Climate

We have analysed rainfall (Table 12.1) and temperature (average, maximum and minimum; Tables 12.2, 12.3 and 12.4) data for the pre-monsoon, monsoon, post-monsoon and winter seasons for the period from 1948 to 2012. Pre-monsoon rainfall shows nonsignificant (50%) decreasing trend (MK stat  $-0.82$ ,  $-63$  mm/season/year) since the 1990s. Similarly, winter rainfall also follows significant (90%) decreasing trend (MK stat  $-0.82$ ,  $-62$  mm/season/year) since the 1990s. However, the winter rainfall trend shows significant (90%) increasing (MK stat  $1.74$ ,  $9.9$  mm/season/year) trend over the period 1948–2012. Similar to the winter rainfall trend, post-monsoon rainfall also shows significant (99%) increasing trend (MK stat  $2.92$ ,  $93$  mm/season/year) for the period 1948–2012. However, the trend is not significant since the 1990s.

In pre-monsoon, the average and minimum temperatures show (Tables 12.2, 12.3 and 12.4) significant (99–95%) increasing trend (MK stat  $1.87$  and  $3.14$ , respectively) at a rate of change of  $0.9$  °C year<sup>-1</sup> and  $0.02$  °C year<sup>-1</sup>, respectively, over the period 1948–2012. Although the temperature (average, minimum and maximum) shows increasing trends in all the three periods, 1948–1970, 1971–1990 and 1991–2012, the trends are not significant. Monsoon temperature (average, minimum and maximum) also shows significant (99%) increasing (MK stat  $4$ – $5$ ) trend ( $0.2$ – $0.7$  °C year<sup>-1</sup>) for the period 1948–2012. Though the trends are positive for the periods 1948–1970, 1971–1990 and 1991–2012, test statistics are significant (99%) only since the 1990s. Similarly, post-monsoon maximum and average temperature showed an increasing trend (MK stat  $4.14$  and  $3.09$ , respectively) at 99% significant level with a rate of change of  $0.02$  and  $0.01$  °C/year, respectively, over the periods 1948–2012. Test statistics (Tables 12.2, 12.3 and 12.4) also found positive for post-monsoon temperature (average, minimum and maximum) since the 1990s, although the trend is significant only for maximum temperature. The winter temperature shows nonsignificant increasing trends, except the decreasing (MK stat  $-1.41$ ,  $0.05$  °C/year) trend for minimum temperature since the 1990s. Besides analysing weather station data, we have also investigated people's perception (Table 12.5) about the recent climatic trends. While 96% of respondents reported that the temperature is increasing, 92% of respondents reported that rainfall trend is decreasing (Table 12.5).

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## 12.5 Impacts, Adaptation Practices and Determinants of Adaptation

Discussions with the farmers in the wetlands reveal that rising temperature and decreasing trends in rainfall negatively affect the panicle and spikelet initiation time of crops. Table 12.6 depicts the time of panicle and spikelet initiation in crops collected during the FGDs with farmers. Farmers reported panicle and spikelet initiation time according to the Bengali months of the year. Therefore, we have also analysed the trends of Bengali months, as it does not coincide with the season as per the English

**Table 12.1** Trend statistics for rainfall at Narail for the period 1948–2012

Rainfall	Nonmiss	Test stat	Std. dev.	MK-stat	p-value	Covariance	Correlation	Rate of change (mm/year)	r
<b>Monsoon</b>									
1948–2012	64.00	135.00	172.60	0.78	0.43	2,9791.00	1.00	0.12	0.00
1948–1970	23.00	11.00	37.86	0.29	0.77	1433.67	1.00	0.08	0.00
1971–1990	19.00	19.00	28.58	0.66	0.51	817.00	1.00	0.44	0.00
1991–2012	22.00	-1.00	35.46	-0.03	0.98	1257.67	1.00	0.13	0.00
<b>Post-monsoon</b>									
1948–2012	64.00	504.00	172.59	2.92	0.00	29,788.00	1.00	1.04	0.08
1948–1970	23.00	41.00	37.86	1.08	0.28	1433.67	1.00	3.05	0.13
1971–1990	19.00	33.00	28.58	1.15	0.25	817.00	1.00	0.58	0.00
1991–2012	22.00	17.00	35.46	0.48	0.63	1257.67	1.00	1.84	0.03
<b>Pre-monsoon</b>									
1948–2012	62.00	67.00	164.61	0.41	0.68	27,097.67	1.00	0.03	0.00
1948–1970	22.00	-38.00	35.45	-1.07	0.28	1256.67	1.00	-2.65	0.11
1971–1990	18.00	21.00	26.40	0.80	0.43	697.00	1.00	2.63	0.09
1991–2012	22.00	-29.00	35.46	-0.82	0.41	1257.67	1.00	-0.70	0.02
<b>Winter</b>									
1948–2012	64.00	299.00	172.10	1.74	0.08	29,619.00	1.00	0.11	0.02
1948–1970	23.00	71.00	37.64	1.89	0.06	1417.00	1.00	0.35	0.06
1971–1990	19.00	26.00	28.53	0.91	0.36	814.00	1.00	0.41	0.01
1991–2012	22.00	-57.00	35.34	-1.61	0.11	1249.00	1.00	-0.69	0.15

**Table 12.2** Trend statistics for maximum temperature at Narail for the period 1948–2012

Maximum temperature	Nonmiss	Test stat	Std. dev.	MK-stat	p-value	Covariance	Correlation	Rate of changes (°C/year)	r
<b>Monsoon</b>									
1948–2012	64.00	765.00	172.53	4.43	0.00	29,766.33	1.00	0.03	0.26
1948–1970	23.00	-17.00	37.86	-0.45	0.65	1433.67	1.00	-0.01	0.01
1971–1990	19.00	34.00	28.57	1.19	0.23	816.00	1.00	0.05	0.04
1991–2012	22.00	89.00	35.23	2.53	0.01	1241.00	1.00	0.07	0.31
<b>Post-monsoon</b>									
1948–2012	63.00	698.00	168.50	4.14	0.00	28,391.34	1.00	0.02	0.23
1948–1970	22.00	-8.00	35.42	-0.23	0.82	1254.67	1.00	-0.02	0.03
1971–1990	19.00	-19.00	28.55	-0.67	0.51	815.00	1.00	-0.03	0.05
1991–2012	22.00	66.00	35.38	1.87	0.06	1252.00	1.00	0.03	0.16
<b>Pre-monsoon</b>									
1948–2012	62.00	151.00	164.58	0.92	0.36	2,7087.00	1.00	0.00	0.00
1948–1970	22.00	48.00	35.45	1.35	0.18	1256.67	1.00	0.05	0.04
1971–1990	18.00	-13.00	26.36	-0.49	0.62	695.00	1.00	-0.05	0.04
1991–2012	22.00	18.00	35.42	0.51	0.61	1254.67	1.00	0.02	0.01
<b>Winter</b>									
1948–2012	63.00	-248.00	168.53	-1.47	0.14	28,401.34	1.00	0.01	0.03
1948–1970	23.00	-84.00	37.79	-2.22	0.03	1428.00	1.00	-0.06	0.26
1971–1990	18.00	-51.00	26.40	-1.93	0.05	697.00	1.00	-0.05	0.16
1991–2012	22.00	51.00	35.40	1.44	0.15	1253.00	1.00	0.06	0.17

**Table 12.3** Trend statistics for average temperature at Narail for the period 1948–2012

Average temperature	Nonmiss	Test stat	Std. dev.	MK-stat	p-value	Covariance	Correlation	Rate of changes (°C/year)	r
<b>Monsoon</b>									
1948–2012	63.00	919.00	168.54	5.45	0.00	28,405.67	1.00	0.02	0.40
1948–1970	22.00	0.00	35.42	0.00	1.00	1254.67	1.00	0.00	0.00
1971–1990	19.00	21.00	28.58	0.73	0.46	817.00	1.00	0.05	0.13
1991–2012	22.00	132.00	35.45	3.72	0.00	1256.67	1.00	0.05	0.53
<b>Post-monsoon</b>									
1948–2012	61.00	496.00	160.64	3.09	0.00	25,806.67	1.00	0.01	0.13
1948–1970	22.00	9.00	35.46	0.25	0.80	1257.67	1.00	0.00	0.00
1971–1990	17.00	-26.00	24.23	-1.07	0.28	587.33	1.00	-0.04	0.09
1991–2012	22.00	33.00	35.44	0.93	0.35	1255.67	1.00	0.02	0.05
<b>Pre-monsoon</b>									
1948–2012	62.00	308.00	164.60	1.87	0.06	27,094.00	1.00	0.01	0.03
1948–1970	22.00	58.00	35.45	1.64	0.10	1256.67	1.00	0.07	0.16
1971–1990	18.00	10.00	26.38	0.38	0.70	696.00	1.00	-0.01	0.00
1991–2012	22.00	28.00	35.45	0.79	0.43	1256.67	1.00	0.01	0.01
<b>Winter</b>									
1948–2012	63.00	200.00	168.56	1.19	0.24	28,414.00	1.00	0.01	0.03
1948–1970	22.00	-8.00	35.45	-0.23	0.82	1256.67	1.00	0.00	0.00
1971–1990	19.00	37.00	28.55	1.30	0.19	815.00	1.00	0.05	0.12
1991–2012	22.00	12.00	35.45	0.34	0.73	1256.67	1.00	0.01	0.01



**Table 12.4** Trend statistics for minimum temperature at Narail for the period 1948–2012

Minimum temperature	Nonmiss	Test stat	Std. dev.	MK-stat	p-value	Covariance	Correlation	Rate of change (°C/year)	r
<b>Monsoon</b>									
1948–2012	64.00	700.00	172.49	4.06	0.00	29,754.00	1.00	0.02	0.20
1948–1970	23.00	41.00	37.81	1.08	0.28	1429.67	1.00	0.02	0.06
1971–1990	19.00	56.00	28.57	1.96	0.05	816.00	1.00	0.05	0.13
1991–2012	22.00	96.00	35.29	2.72	0.01	1245.33	1.00	0.04	0.25
<b>Post-monsoon</b>									
1948–2012	62.00	16.00	164.56	0.10	0.92	27,079.34	1.00	0.00	0.00
1948–1970	23.00	30.00	37.82	0.79	0.43	1430.00	1.00	0.02	0.02
1971–1990	17.00	-53.00	24.26	-2.19	0.03	588.33	1.00	-0.08	0.20
1991–2012	22.00	8.00	35.45	0.23	0.82	1256.67	1.00	0.00	0.00
<b>Pre-monsoon</b>									
1948–2012	63.00	530.00	168.54	3.14	0.00	28,404.67	1.00	0.02	0.16
1948–1970	23.00	99.00	37.86	2.61	0.01	1433.67	1.00	0.09	0.27
1971–1990	18.00	28.00	26.29	1.06	0.29	691.33	1.00	0.04	0.03
1991–2012	22.00	12.00	35.38	0.34	0.73	1252.00	1.00	0.02	0.05
<b>Winter</b>									
1948–2012	63.00	499.00	168.57	2.96	0.00	28,414.33	1.00	0.02	0.16
1948–1970	23.00	37.00	37.84	0.98	0.33	1431.67	1.00	0.03	0.06
1971–1990	18.00	69.00	26.40	2.61	0.01	697.00	1.00	0.15	0.41
1991–2012	22.00	-50.00	35.42	-1.41	0.16	1254.67	1.00	-0.05	0.14

**Table 12.5** Farmers perception on climate change impacts and adaptation in wetlands ( $N = 103$ )

Variable	Percentage (%)
Changes in temperature	
Increasing	96
Decreasing	4
Stayed the same	0
Changes in rainfall	
Increasing	5
Decreasing	92
Erratic	1
Stayed the same	2
Impact of rainfall and temperature changes in production	
Yes	99
No	1
Adaptation in agriculture	
Changes of crop varieties	12
High quantity of fertilizer	5
Increase in irrigation	3
Multiple coping strategies	80
Adaptation in water sector	
Use of boring methods	94
River water	1
Prevent saline water	1
Doing nothing	4
Loan taken	
Yes	8
No	92
Concern about climate change	
Yes	75
No	25

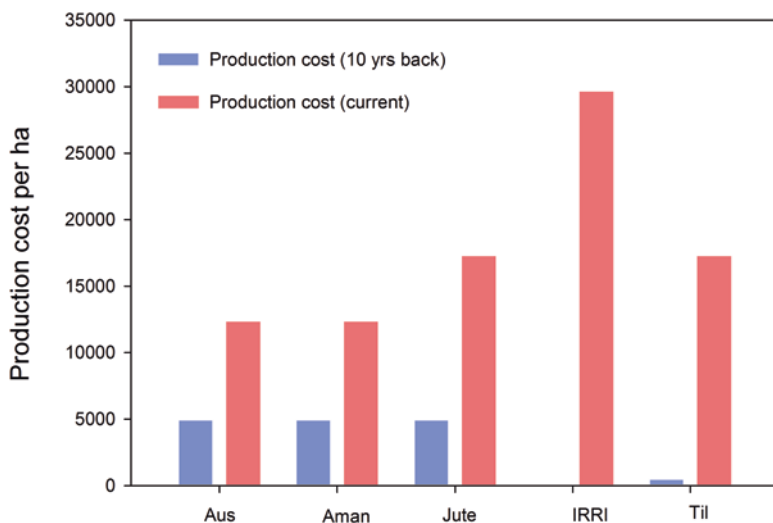
**Table 12.6** Panicle and spikelet initiation time for the local crops

Crop types	Panicle and spikelet initiation time
<i>Til</i>	<i>Chaitra</i> (mid-March to mid-April)
<i>Aus</i>	<i>Ashar-Joistha</i> (mid-June to mid-August)
<i>Aman</i>	<i>Ashin-Kartik</i> (mid-September to mid-November)

months. The trend analysis revealed that, though the rainfall trends are decreasing only for the *Joistha* (May–June) and *Kartik* (October–November), the mean and maximum temperatures are following significant increasing trends from 1948 to 2012. This rising temperature and decreasing rainfall coincide with the panicle and spikelet initiation time of local crops such as *Aus* (autumn/pre-kharif rice crop), *Aman* (winter/kharif rice crop) and *Til* (sesame seed). The rising temperature negatively affects agriculture by burning out the production. The rising temperature in monsoon,

post-monsoon and pre-monsoon seasons and decreasing rainfall trends in pre-monsoon season are the reasons for changing the crop varieties in the wetlands. Although the growing demands of food due to the rising population forced the government to develop policies friendly to high-yielding varieties (HYV), the changes in climate are also a reason for adopting HYV crops. During the survey, ~99% of farmers perceived that changes in rainfall and temperature negatively affected crop production in the wetlands. While coping with these negative effects of climate change, 80% of farmers have adopted multiple adaptation methods that include changes in crop varieties and excessive use of fertilizers, whereas ~12% of farmers adopted only changes in crop varieties as an adaptation option. Furthermore, 94% of farmers are adopting expensive borewells as an adaptation in water resources required for crop production in wetlands. Farmers reported that the local crops cultivated before the 1990s did not require such borewells, as means of adaptations, whereas the new HYV crops' production costs are very high. Figure 12.2 shows that the production cost has increased 2.5–3.5-fold within 10 years of time due to the shift from local crops to HYV crops.

We explored the determinants of adaptation by running bivariate probit regression (BPR) with age, education and income as explanatory variables. Table 12.7 shows that education positively ( $\beta = 0.06, p < 0.05$ ) influenced adaptation practices in agriculture, whereas the rest of the variables exhibited no influence. Further, we added some more explanatory variables such as access to credit, climate change concerns (e.g. yes or no) and impact of rain and temperature on agriculture along with the earlier three explanatory variables. This exhibited no influence of education on adaptation; however, adaptation exhibited ( $\beta = 1.00, p < 0.1$ ) significant relationship with loan taken. This possibly implies that adaptation to climate change is influenced mostly by the loan, as the farmers are depending on loan to cope with increase in production cost.



**Fig. 12.2** Production costs of local crop varieties in wetlands

**Table 12.7** Determinants of climate change adaptation

Variables	(1)	(2)	(3)	(4)
	Adapt dummy	Water dummy	Adapt dummy	Water dummy
Age	−0.00 (0.01)	0.01 (0.01)	−0.00 (0.01)	0.01 (0.01)
Educational	0.06* (0.03)	−0.05 (0.04)	0.04 (0.03)	−0.05 (0.04)
Income	−0.07 (0.16)	0.10 (0.22)	−0.08 (0.16)	0.11 (0.23)
Loan			1.00* (0.52)	−0.40 (0.64)
Concern about climate change			0.36 (0.39)	−0.47 (0.61)
Impact of rainfall and temperature changes			5.22 (1678)	−4.06 (3095)
Constant	−0.20 (1.66)	0.26 (2.30)	−5.73 (1678)	4.74 (3095)
Observations	93	93	93	93

Standard errors in parentheses

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

## 12.6 Future Impacts and Adaptation to Climate Change in Wetlands

Our previous work (Hossain et al. 2013) projected climate change for the same study area using MAGICC (Model for the Assessment of Greenhouse Gas Induced Climate Change)–SCENGEN (SCENario GENerator) model. This study also investigated the plausible impacts of future climate using expert judgement and literature review. The model projection shows that monsoon and post-monsoon rainfall will increase 10–23% by 2100. Similarly, temperature will increase 2–5 °C in all seasons by the year 2100. For the predicted changes in temperature and rainfall, crop production will decline by 30–35% for *Aus* (autumn/pre-kharif rice crop) and 22–63% for wheat. The fall in production will influence food security of this region, as these crops are the staple food not only for the wetland-based people but also the whole population of the country. The changes in climate will also increase irrigation demand, which in turn will increase production cost in agriculture. In addition, salinity and water scarcity will also increase due to the changes in climate, which will also increase production cost, with a possibility of production loss in wetlands at Narail. Moreover, natural hazards such as floods will also increase (25–50%) in the region.

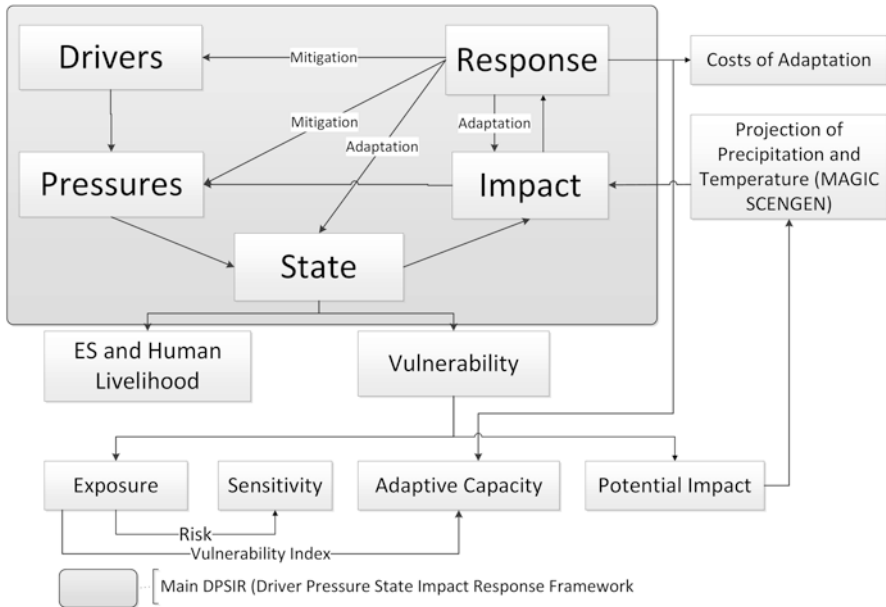
Hossain et al. (2013) also identified adaptation and mitigation options using interdisciplinary framework DPSIR [driver-pressure-state-impact-response], (Fig. 12.3) to adapt to climate change in these wetlands. They recommended

maintaining water flow required in dry season and construction of barrage to store water in dry season. Mitigation options such as dredging rivers and excavating canals in wetlands were also identified as the possible mitigation options to climate change. In case of adaptation to current state and future impacts, fair trade policy at least could ensure recovery from the loss of high production cost and other impacts due to climate change. In addition, increasing the capacity of farmers through training and education could enhance their capacity to adapt with climate change. Adaptation options such as new varieties with low production cost and increase in the access of fertilizers and energy could help the community to cope with climate change. Moreover, low-cost technology such as rainwater harvesting could help in storing water during wet season for the use in dry season for household and irrigation purposes. These recommendations were for ecosystem service-based adaptation (ESbA) concerning the social–ecological system of wetlands.

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## 12.7 Mainstreaming Climate Change in Development Planning

Adaptation to climate change is highly challenging for the development in low-income countries. Despite greater emphasis on mainstreaming climate change adaptation into development planning (Schipper 2007; OECD 2009), it is in relatively early stage in many countries (UNEP 2011). One of our previous works (Hossain et al. 2010) is focused on mainstreaming climate change adaptation in the same wetlands that we are focusing in this chapter. Hossain et al. (2010) investigated whether the government was concerned about climate change while planning water resource management project in wetlands. Surveys and FGDs were used to collect the impacts of climate change in the study area. National Adaptation Programme of Action (NAPA) and the project documents of water resources were reviewed to investigate whether climate change was one of the concerns while planning and implementing the project. As we have already discussed about climate change impacts using trends and survey data analyses, we will now focus only on the mainstreaming of climate change adaptation in this section. Although the water resource management project adopted some of the initiatives such as canal excavation and embankment construction to increase water availability in wetlands, the project was not concerned about climate change while in its planning stage. National Adaptation Programme of Action (NAPA 2005) identified the wetland area as drought prone area; however, the project did not consider the mitigation and adaptation to drought in the wetlands. The project also did not consider the current and future impacts of climate change, or it did not consider how it would adapt to climate change. Though the project claimed that water demand would increase after the implantation of the project, water scarcity in wetlands may increase because of not linking climate change with water demand and feedbacks from society such as extraction of more groundwater in response to increasing water demand due to climate change. Moreover, the important question is how the water resource management initiatives will adapt with the excess of water in the wet season and scarcity of water in the dry



**Fig. 12.3** Modified DPSIR to demonstrate integration of climate change adaptation into development plans (Source: Hossain et al. 2013)

season in the future. NAPA (2005) and Bangladesh Climate Change Strategy and Action Plan 2009 (MoEF 2009) emphasized mainstreaming of climate change in the country and provided guideline for climate change adaptations. However, previous studies did not provide insight on how we can integrate adaptation planning in the real world. Hossain et al. (2013) provided a conceptual model to integrate climate change adaptation within development plans. In brief, the modified versions of DPSIR framework (Fig. 12.3) identify the drivers and pressures using secondary data and community engagement and also identify the state by analysing the vulnerability of the wetlands. The future impacts were then assessed by using MAGICC/SCENGEN model to project future climate. The response part of the DPSIR integrates how we can mitigate the drivers and pressures and how we can adapt with current state and future impacts using ecosystem service-based adaptation.

## 12.8 Why We Still Need to Know About Local Climate Change Adaptation?

Despite the significant contribution of wetlands to the national and regional (South Asia) economy, impacts and adaptation to wetlands were given low attention in Bangladesh in particular, and South Asia in general. Therefore, this study explores the opportunity for adaptation planning at local and national level through local

knowledge on climate change in wetlands. Engaging with the community to understand their perception on climate change impacts and adaptations has been recognized as an intuitive way to get insight into climate information and as a tool for communication with local people (Reyes-García et al. 2016). The real-world example of not integrating climate change adaptation into development planning despite emphasis on mainstreaming climate change adaptation in national planning provides indication that there is a need for developing robust and more effective planning to cope with climate change at local level. In addition, the influence of loan on adaptation to climate change also suggests to increase the access to credit and microfinance for promoting sustainable agriculture and to tackle climate change impacts. Although the microfinance and access to credit are set among the Sustainable Development Goals (SDGs) for ending poverty, these are not included for promoting sustainable agriculture and achieving climate change goals identified in the SDGs. In addition, the dependency of agriculture production on subsidy and the necessity of shifting to crop varieties with low production cost have been neglected while setting the SDGs. Without including these issues in local and global agenda, the rising production cost may demotivate farmers in the long run, and it could jeopardize in achieving some of the SDGs such as ending poverty by 2030. Therefore, the local adaptation study not only can influence adaptation planning at different scales but also can contribute in developing global targets such as SDGs. This study can be extended by increasing sample size and extending this study to other wetlands. Moreover, answering some of following research questions can provide insight into the impacts of climate change on wetlands and ways to develop effective adaptation plans. The research questions may include:

- Do the wetland management plans integrate national adaptation planning?
- How can we reduce cost of production using wetland resources?
- How the wetland ecosystem services can play a role in adaptation to climate change?
- How to develop tools/framework/model to integrate adaptation planning into development planning?
- How local wetlands can contribute to the mitigation of climate change at global and national scale?
- What are the limits of adaptation to climate change concerning the social–ecological systems of wetlands?

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