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Assessment on Long–Term Meteorological Data and Farmer's Perception towards the Impact of Climate Change during Past 30 Years

Shifat Ara[1,2*], and M. A. Sattar[1]

[1]Bangabandhu Sheikh Mujibur Rahman Science and Technology University, Gopalganj-8100, Bangladesh.
[2]Department of Agriculture Extension, Ministry of Agriculture, Bangladesh.

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***Corresponding author:**

shifat.ur.03@gmail.com

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Abstract

Climate change has emerged as one of the most serious dangers to people's lives and livelihoods throughout the world in recent years. Bangladesh is one of the world's most susceptible countries to climate change. The country is already dealing with the impacts of climate change, such as increased cyclones, flood frequency, and river erosion. Reduced agricultural production, as well as cropping intensity, have impacted people in many coastal areas. Long-term meteorological data (past 30 years) was used in the study to assess climate change scenarios in the South-West coastal region of Bangladesh. The annual variation of climatic factors during past 30 years of the study areas were collected through Focus Group Discussion (FGD). The Mann-Kendall Trend Test was used to evaluate the accumulated data over time for consistent increasing or decreasing trends in each study area. The maximum and minimum annual temperature was steady increasing trend. Besides that, annual rainfall and humidity showed irregular patterns of increasing and decreasing. Agricultural production was decreased after the year 2012 in those areas. This study will be helpful to determine the barriers to good agricultural production in coastal areas.

Keywords: Climate change, meteorological data, coastal area, and agriculture.

Introduction

Due to climate vulnerabilities, people living in various coastal areas of Bangladesh have experienced lower crop productivity and cropping intensity. Natural disasters strike Bangladesh almost every year as a result of climate change. Crop agriculture is often constrained by different hazards and disasters such as floods, droughts, soil and water salinity, cyclones and storm surges (MoEF, 2009b).

The physiography of Bangladesh is characterized by two distinct features: a large, flood-prone deltaic plain and a small hilly area, which is flowing quickly across rivers. The country stretches 820 kilometers north to south and 600 kilometers east to west, covering 144,000 square kilometers. Bangladesh is bounded on the west, north, and east by a 2,400-kilometer land border with India, and on the southeast by a 193-kilometer land and water border with Burma. The south boasts a 600-kilometer-long deltaic coastline riven by several rivers and streams that drain into the Bay of Bengal. The territorial waters of Bangladesh stretch over 12 nautical miles and the exclusive economic zone of the country stretches over 200 nautical miles. Due to its geographical position, the domination of flood-lands and low topography, the high population density, high rates of poverty and an overwhelming dependence on the environment, many of which have a sensitivity to the climate.

Bangladesh is predominantly an agricultural and densely populated country having 16 million people. (BBS, 2010). Growing populations, poverty reduction, food security, and climate change adaptation are all challenges that agriculture can help to solve (BCCAAP, 2010; BPRSP, 2005). In coastal areas, it has been identified as a critical factor in achieving development goals (BPRSP, 2005). About 40 million people of the coastal areas of Bangladesh depend on agriculture (BBS, 2011). For a long period, the coastal districts' exposure to recurring stresses and sudden shocks of nature has had a detrimental effect on one of the primary livelihoods of the coastal community, which is crop agriculture. Following a significant natural disaster, agricultural activities in the coastal area become inactive for an extended period of time, jeopardizing the coastal community's food security and socioeconomic standard. (Saha *et al.*, 2016). The variability of climate change has become a challenging issue for agriculture due to global warming. Agricultural crops of Bangladesh are especially sensitive to the different variables of climate such as temperature, rainfall, humidity, day-length etc. as well as different natural disasters like floods, drought, salinity and storm surges etc. Moreover, global climate change asserts a new depressing effect to the lives and agro economy of the whole world and Bangladesh is not out of its grip as well (Saha *et al.*, 2016). According to IPCC 5th Assessment Report, global climate change is likely to further aggravate the flooding and salinity situations of South-Asian countries including Bangladesh. Though the climate change is adversely affecting each and every sector, their impacts are going to be much higher on agriculture sector, worst affecting the agriculture dependent livelihood resources (LACC, 2008). The IPCC estimates that by 2050 rice production in Bangladesh could decline by 8% and wheat by 32% (against a base year of 1990) due to higher temperature and higher CO2 concentration (IPCC, 2001).

Many studies have been conducted in the past on the impact of climate change by predicting temporal variations of various factors. However, in this study, long-term meteorological variation over the last 30 years is being analyzed to determine a clear scenario for Bangladesh's south west region. Furthermore, the trend analysis is carried out using a well-known hypothesis testing method that is followed by a few literatures. Aside from that, farmers' perceptions are counted as qualitative data. Hopefully, the findings of this study will be very useful in carrying out additional research on crop production and adaptation in the chosen study area.

Materials and methods

Design of the Study

This study followed different approaches for its completion. Reconnaissance survey was conducted the on field activities. The relevant long-term meteorological data was collected through Bangladesh Meteorological Department (BMD). The farmers' perception towards magnitude, trends and impacts of climate change was collected through Focus Group Discussion (FGD).

Selection of the Study Area

Study area was selected according to objective of the study. South-West coastal region of Bangladesh is highly vulnerable to disaster. Khulna is considered as highly disaster prone district in South-West Bangladesh. So, 6 No. Koyra village of Koyra upazila and Bayerbhanga village of Batiaghata upazila under Khulna district and Faloibunia village of kowkhali upazilla under Pirojpur District are being selected primarily as study area because of severity of natural hazards like river erosion, salinity intrusion and cyclone. Homogeneity and good communication system is also the key factors.

Sampling method and sampling size determination

Sample Unit

Farmer's Households was taken as a sampling unit. Households was selected based on random sampling among the inhabitants of the villages. The household members whose ages were more than 30 years and who had vast knowledge and experience regarding climate change and agriculture were treated as sampling units.

Sampling Size

A total of 506 farmer's households (HH) were recorded from Bayerbhanga village, 284 farmer's HH from 6 no. Koyra village and 435 farmer's HH from Faloibunia village. (Source*: Upazila Parishad, 2019*). The sample size for the farmer's households was determined following Kothari (1990),

$$n = \frac{z^2 pqN}{e^2(N-1) + z^2 pq}$$

Where,

N = population size; n = sample size; p = sample proportion; q = 1-q;

z = standard variate at a given confidence level; and e = acceptable error (the precision) at 99% confidence level. z = 2.5758 at 99% confidence level; p = 0.1; q = (1-0.1) = 0.9; e = 0.05

Assessment of the trends of climate change

Mann-Kendall Test

Mann-Kendall test (Mann, 1945; Kendall, 1975) is a commonly used nonparametric test to assess trends in hydrological time-series. It can be viewed as a nonparametric test for zero slope of the linear regression of time-ordered data with time (Gilbert, 1987, Hollander and Wolfe, 1973). In case of Mann-Kendall test, the null hypothesis (Ho) represents the case when there is no trend in the record, while the alternative hypothesis (Ha) indicates the existence of an upward or downward monotonic trend in the data. In this study, Mann Kendall Trend Test was used to examine the trend of climate change using a number of variables such as rainfall, temperature, and humidity.

Results and Discussion

Assessment of Long Term Meteorological Data

Annual Maximum and Minimum temperature

In Khulna region, the fluctuation of minimum and maximum temperature was moderate with respect to last 30 years. It was observed that the maximum temperature fluctuation of first 10 years (1989-1999) was not same in every year. The highest temperature was recorded 40 degree Celsius in 1989 and the lowest maximum temperature was 36.5 degree Celsius in 1993 and 1997. On the other hand, the highest minimum temperature was recorded 9.5 degree Celsius in 1999 and the lowest minimum temperature was 7 degree Celsius in 1993 (Figure 1).

It is also observed that, the fluctuation of maximum temperature was slightly uniform from 2000 to 2010. The highest temperature was recorded 40.5 degree Celsius in 2009 and the lowest maximum temperature was 37.5 degree Celsius in 2003. On the other hand, the minimum temperature had been recorded 10.1 degree Celsius in 2002 and the lowest minimum temperature was 6.4 degree Celsius in 2003.

In last several years (2011-2019), the fluctuation of both maximum and minimum temperature was not uniform. The highest temperature was recorded 40.7 degree Celsius in 2014 and the lowest maximum temperature was 34.6 degree Celsius in 2019. On the other hand, the minimum temperature has been recorded 12.4 degree Celsius in 2019 and the lowest minimum temperature was 7 degree Celsius in 2013.

So, it is observed that the temper\ature of Khulna region has been increased on recent years according to the meteorological data. In 2019, the temperature fluctuation is noticeable where the lowest maximum temperature and highest maximum temperature is being observed with respect to last 30 years (Figure 1).

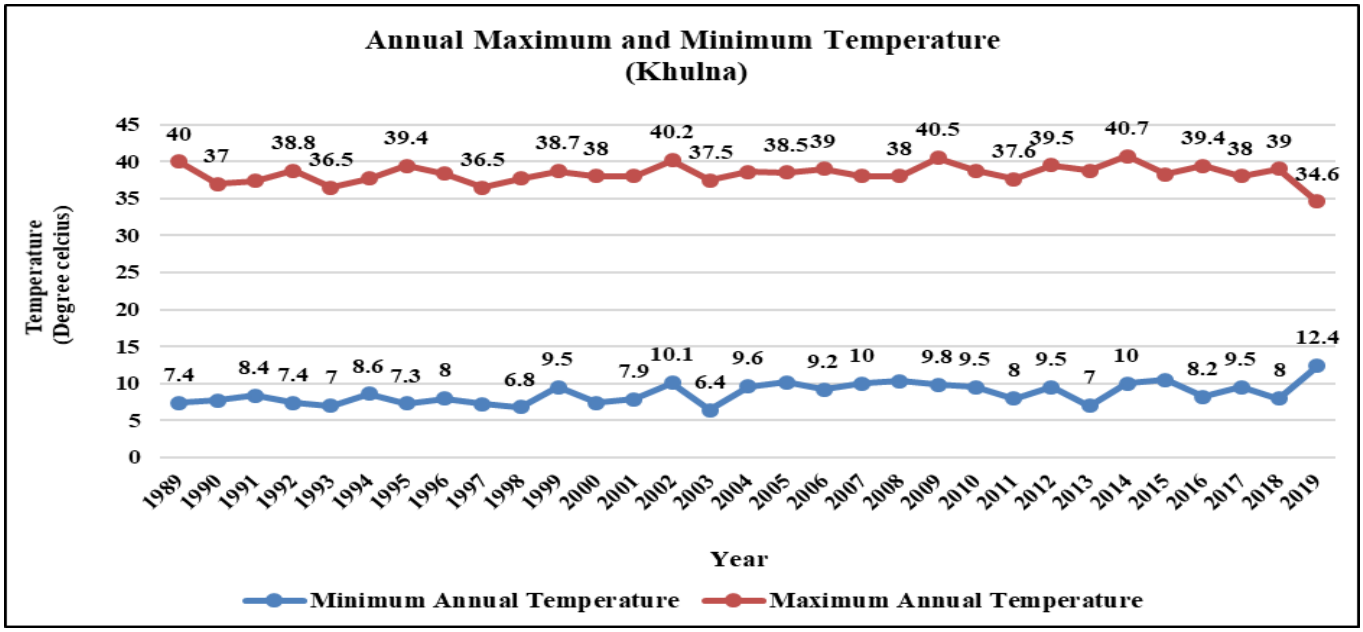

Figure 1. Long term (1989-2019) trend of maximum-minimum temperature in Khulna.

Table 1. Mann-Kendall trend test / Two-tailed test (Minimum Annual Temperature, Khulna)

Kendall's tau	-0.098
S	-10.000
Var(S)	402.667
p-value (Two-tailed)	0.654
alpha	0.050

An approximation has been used to compute the p-value.

Test interpretation
Ho: There is no trend in the series
Ha: There is a trend in the series
As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis Ho. The continuity correction has been applied.

Table 2. Mann-Kendall trend test / Two-tailed test (Maximum Annual Temperature, Khulna)

Kendall's tau	-0.059
S	-6.000
Var(S)	402.667
p-value (Two-tailed)	0.803
alpha	0.050

An approximation has been used to compute the p-value.

Test interpretation
H0: There is no trend in the series
Ha: There is a trend in the series
As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0. The continuity correction has been applied.

The findings of the long term temperature data showed a steady increasing trend of both maximum and minimum temperatures over time for both study area (Figure 1). It was observed that the minimum temperature during winter season had been slightly decreasing (December-January). In 2019, minimum temperature increased in both areas, while the maximum temperature decreased slightly.

In Pirojpur region, the fluctuation of minimum and maximum temperature was also moderately uniform like Khulna with respect to last 30 years (Figure 2). It was observed that the maximum temperature fluctuation of first 10 years (1989-1999) was not same in every year and temperature range is slightly lower than Khulna area. The highest temperature has been recorded 39.4 degree Celsius in 1990 and the lowest maximum temperature was 35.6 degree Celsius in 1997. On the other hand, the highest minimum temperature had been recorded 9.6 degree Celsius in 1999 and the lowest minimum temperature was 7 degree Celsius in 1993 and 1998.

It is also observed that, the fluctuation of maximum temperature was uniform from 2000 to 2010. The highest temperature had been recorded 37.6 degree Celsius in 2001 and the lowest maximum temperature was 36 degree Celsius in 2002. On the other hand, the highest minimum temperature had been recorded 9.6 degree Celsius in 2005 and the lowest minimum temperature was 7.3 degree Celsius in 2003 (Figure 2).

In last several years (2011-2019), the fluctuation of both maximum and minimum temperature was not uniform also like Khulna region. The highest temperature had been recorded 39 degree Celsius in 2014 and the lowest maximum temperature was 35.4 degree Celsius in 2019. On the other hand, the highest minimum temperature had been recorded 12.6 degree Celsius in 2019 and the lowest minimum temperature was 6.5 degree Celsius in 2013 and 2018 (Figure 2).

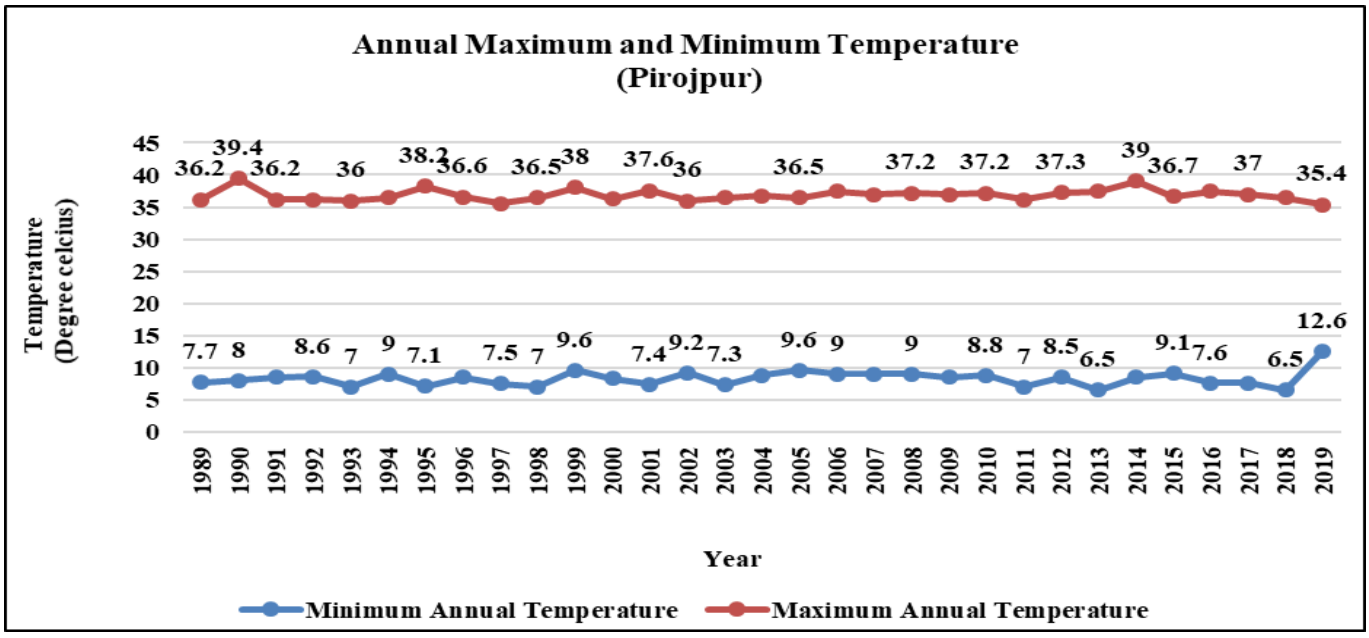

Figure 2. Long term (1989-2019) trend of maximum-minimum temperature in Pirojpur

Table 3. Mann-Kendall trend test / Two-tailed test (Minimum Annual Temperature, Pirojpur)

Kendall's tau	-0.347
S	-35.000
Var(S)	399.000
p-value (Two-tailed)	0.089
alpha	0.050

An approximation has been used to compute the p-value.

Test interpretation
Ho: There is no trend in the series
Ha: There is a trend in the series
As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis Ho. The continuity correction has been applied.

Table 4. Mann-Kendall trend test / Two-tailed test (Maximum Annual Temperature, Pirojpur)

Kendall's tau	-0.089
S	-9.000
Var(S)	399.000
p-value (Two-tailed)	0.689
alpha	0.050

An approximation has been used to compute the p-value.

Test interpretation
Ho: There is no trend in the series
Ha: There is a trend in the series
As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis Ho. The continuity correction has been applied.

So, the linear graph (Figure 2) indicates that, the temperature of Pirojpur is not as higher as Khulna region according to meteorological data. Also in this area, the data of 2019 is noticeable as the lowest maximum temperature and highest minimum temperature has been fluctuated dramatically with respect to last 30 years. So, it might be impactful for agricultural production in Pirojpur region at 2019.

Total Annual Rainfall

In Khulna, it was observed that (Figure 3), the annual rainfall from 1989 to 1999 was not uniform yearly. Noticeable fluctuation was observed in 1992 for lowest rainfall (1439 mm) and in 1993 for highest rainfall (2079 mm). From 2000 to 2010, there was a huge fluctuation of annual rainfall in 2002 for highest rainfall (2594mm) where lowest rainfall was 1357 mm in 2010. From 2011 to 2019, un uniformed fluctuation of annual rainfall was being noticed where the lowest rainfall was recorded 1073 mm in 2018 and the highest rainfall was 2317 mm in 2015. From 2015 to 2017, the rates of annual rainfall were slightly higher in this time period (2011-2019). But, if the overall data of 30 years is noticed, there is observed that, annual rainfall decreased in shortly in last 30 years. Both over rainfall and short rainfall is harmful for agricultural production. So, the production of crops or vegetables have might been hampered in this area in that years with higher or lower rainfall.

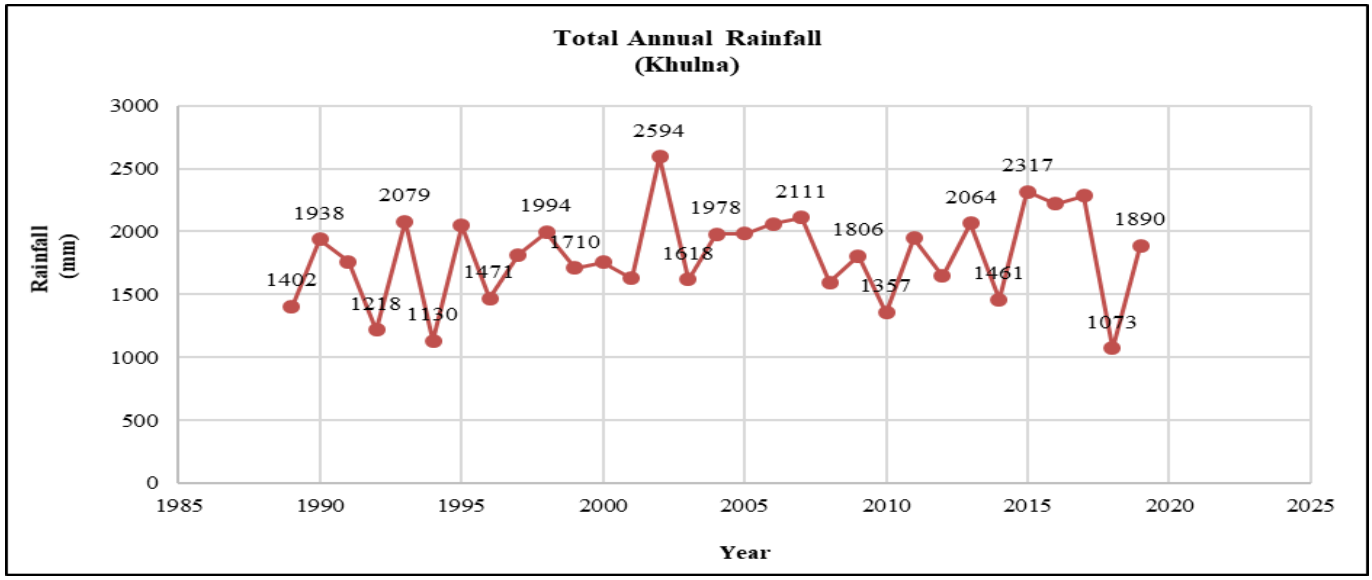

Figure 3: Long term (1989-2019) trend of total annual rainfall in Khulna.

Table 5. Mann-Kendall trend test / Two-tailed test (Total Annual Rainfall, Khulna):

Kendall's tau	0.029
S	3.000
Var(S)	408.333
p-value (Two-tailed)	0.921
alpha	0.050

Test interpretation:
Ho: There is no trend in the series
Ha: There is a trend in the series
As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis Ho**.** The continuity correction has been applied.

Similarly, in Pirojpur, it was observed that (Figure 4), the annual rainfall from 1989 to 1999 is not uniform yearly. Noticeable fluctuation was observed in 1994 for lowest rainfall (1130 mm) and in 1998 for highest rainfall (2858 mm). In this year, severe flood had occurred in Bangladesh where agricultural production damaged severely.

From 2000 to 2010, there was ununiformed fluctuation of annual rainfall where highest rainfall (2537 mm) was observed in 2002 and lowest rainfall was 1770 mm in 2000. Also from 2011 to 2019, ununiformed fluctuation of annual rainfall was being noticed where the lowest rainfall was recorded 1418 mm in 2018 and the highest rainfall was 2624 mm in 2017. According to the meteorological data of last 30 years, Pirojpur district faces high rainfall most of the year. Due to over rainfall, there might be loss of agricultural production annually. But in case of riverine area, this area faces the challenges of extreme flood and river erosion. So, this fact would be clarified by open discussion with the farmers in that area. There was sharp decreasing trend of annual rainfall in both locations from 2017 to 2019 which indicates that annual rainfall is decreasing in the recent years. This decreasing trend of annual rainfall might have hampered overall crop production in the selected study areas. Decreasing trend of winter season rainfall is associated with higher rate of increase in minimum temperature (Wang et al. 2009) that might have hampered the growth of the vegetation.

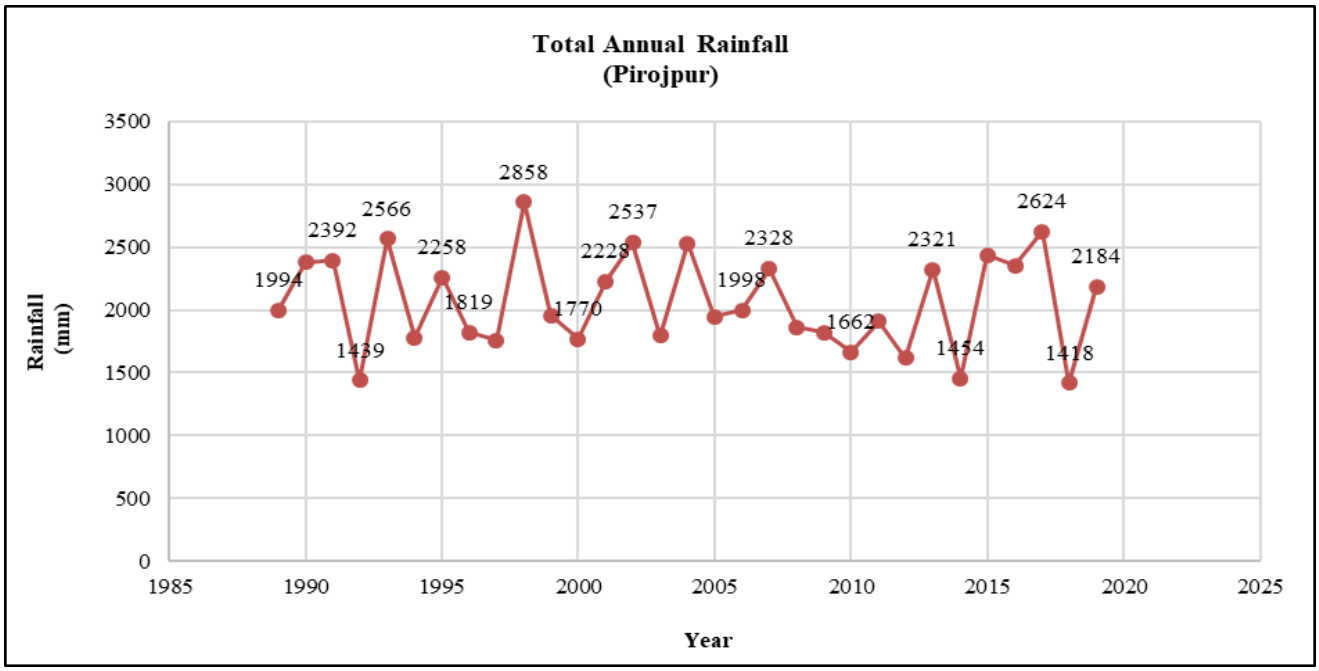

Figure 4: Long term (1989-2019) trend of total annual rainfall in Pirojpur

Table 6. Mann-Kendall trend test / Two-tailed test (Total Annual Rainfall, Pirojpur)

Kendall's tau	0.029
S	3.000
Var(S)	408.333
p-value (Two-tailed)	0.921
alpha	0.050

An approximation has been used to compute the p-value.

Test interpretation
Ho: There is no trend in the series
Ha: There is a trend in the series
As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis Ho. The continuity correction has been applied.

Both study sites are lying on coastal region. Salinity is a common issue in this area, basically in Khulna. In dry season the increased salinity in soil and water might causes less production of crops and vegetables in this area. In this case, heavy rainfall would decrease the rate of salinity in both soil and water. Besides that, the farmers would have adopted the cultivation of saline tolerant crops; rainfall would be a very much important factor in this region. South west region is the lower part of Bangladesh where excessive rainfall causes severe flood and extended flooding of arable land narrowing scope for crop production, especially in the vast low land areas.

Annual Average Humidity

The analysis of long-term humidity database reflected that change of annual average humidity pattern was not definite over seasons. Both in Khulna and Pirojpur there was observed (Figure 5 and 6) a huge fluctuation in almost every year.

In Khulna, annual average humidity from 1989 to 1999 shows that, there had been a dramatic change on humidity fluctuation after 1989. In 1989, it had been recorded the lowest (78.3%) humidity in this time period and in 1990, it had been recorded highest (81.8%). Also from 2000 to 2010, it was observed a great fluctuation of humidity after 2004 where it was recorded the highest humidity (81.5%) in 2005 and the lowest (78.7%) in 2006. From 2011 to 2019, the record of annual average humidity shows rapid increase after 2011. In 2012, it had been recorded highest humidity (82.3%) and in 2014 was the lowest (78%). From 2015 to 2017, it was observed almost same amount of humidity in every year.

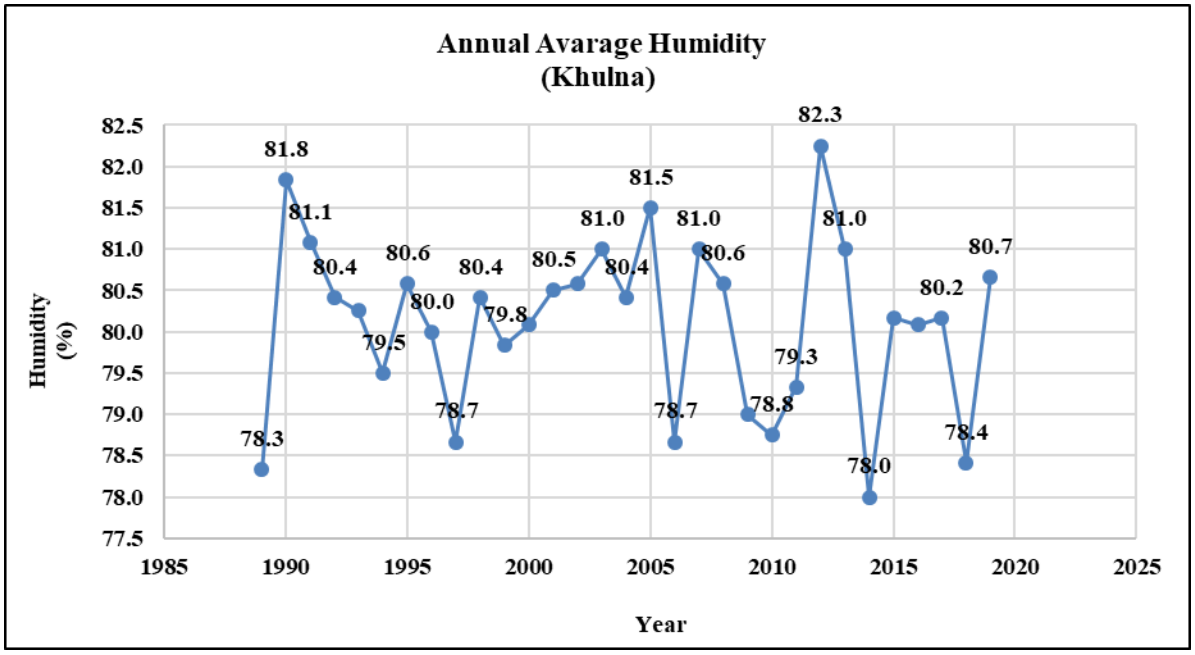

Figure 5: Long term (1989-2019) trend of annual average humidity in Khulna.

Table 7. Mann-Kendall trend test / Two-tailed test (Annual Average humidity, Khulna)

Kendall's tau	-0.095
S	-9.000
Var(S)	378.333
p-value (Two-tailed)	0.681
alpha	0.050

An approximation has been used to compute the p-value.

Test interpretation

Ho: There is no trend in the series

Ha: There is a trend in the series

As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis Ho. The continuity correction has been applied.

Similarly, in Pirojpur (Figure 6), annual average humidity from 1989 to 1999 shows that, there had been uniformed change on humidity in every year. In 1989, it had been recorded the lowest (82.8%) humidity in this time period and in 1993, it was recorded highest (84.8%). Also from 2000 to 2010, it is observed a great fluctuation of humidity after 2004 where it was recorded the highest humidity (85.1%) in 2005 and the lowest (82%) in 2009

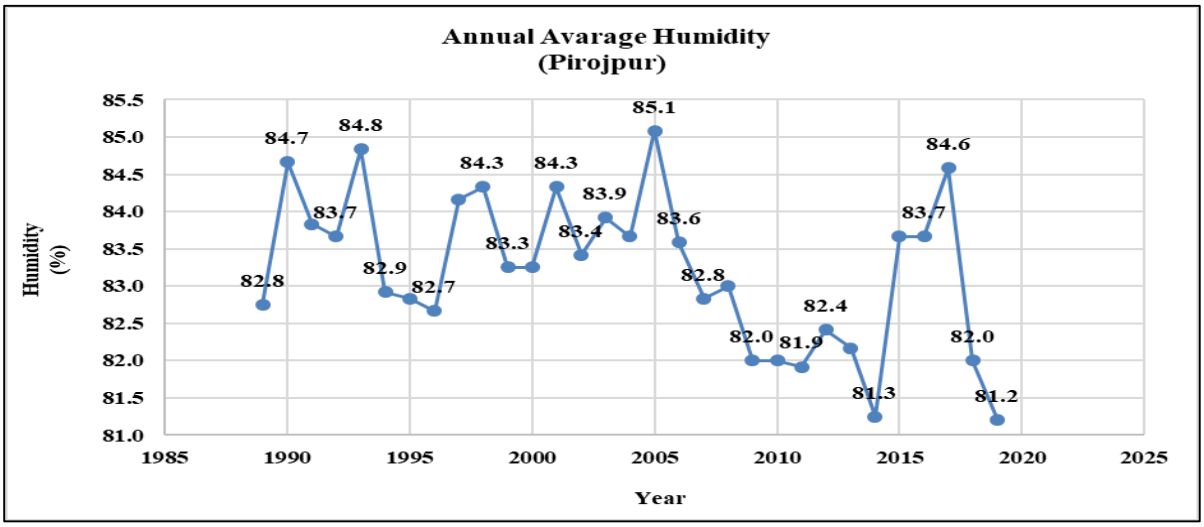

Figure 6. Long term (1989-2019) trend of annual average humidity in Pirojpur.

and 2010. From 2011 to 2019, the record of annual average humidity showed rapid increase after 2014 and decrease after 2017. In 2017, it had been recorded highest humidity (84.6%) and in 2019 was the lowest (81.2%). After 2017, there was a dramatic decrease of humidity in every year.

Table 8. Mann-Kendall trend test / Two-tailed test (Annual Average humidity, Pirojpur)

Kendall's tau	-0.228
S	-21.000
Var(S)	367.667
p-value (Two-tailed)	0.297
alpha	0.050

An approximation has been used to compute the p-value.

Test interpretation
Ho: There is no trend in the series
Ha: There is a trend in the series

As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis Ho. The continuity correction has been applied.

In both study area, the fluctuation of humidity or relative humidity is noticeable due to the trend of climate change in last 30 years. Size of crops and growth of plants might also be fluctuates almost in every year. Besides that, crops would more susceptible to a variety of diseases, fungus and parasites that thrive in humid conditions. As, this areas are lying on coastal belt, some other climatic factors would be taken into action for perfect growth of plants. Soil salinity is a unique issue in this area. Temperature and moisture content is also to be considered.

Farmer perception of climate change

People living in different coastal areas of Bangladesh are seriously suffering lower crop productivity and very low cropping intensity because of different climatic hazard. The participant of selected area was given the following opinion regarding the impact of climate change (Table 9).

Respondents perceived that temperature was increased over the year which cause more insect and disease infestation in different crops. For example, after the cyclone "BULBUL" the standing crop in the field was T-aman which devastatingly attacked by 'Rice bug' caused serious damage and people were not able to harvest it. People also mention that the duration of winter had been shortened affecting the potential growing period of winter crop.

Rainfall is one of the major climatic factors for crop production. All crops have critical stage when it needs water for its growth and development. It was found that 1mm increase in rainfall at vegetative, reproductive and ripening stages decrease Aman rice production by 0.036, 0.230 and 0.292 ton respectively. (IBID). People in the survey stated that due to irregular rainfall, crop production was hampered. Moreover, low amount of rainfall in Boro season increase soil salinity in coastal area. Coastal people changed their seed sowing and transplanting time due to scarcity of water.

Climate change impact on Bangladesh is not a future issue. The country is affected by salinity, flood, drought, temperature variations, erratic rainfall etc. which result in crop losses. Farmer in the study area said relative

Table 9. Farmers' perception on climate change in the southwest costal area of Bangladesh

Climate factors		Areas						P value & level of sig.
		Bayerbhange, N=145		6 No. Koyra, N=130		Faloibuniya, N=146		
		Count	%	Count	%	Count	%	
Rainfall	Unchanged	25	17.2	7	5.4	31	21.2	0.001**
	Decreased	42	29.0	89	68.5	57	39.0	
	Increased	78	53.8	34	26.2	58	39.7	
Temperature	Unchanged	8	5.5	1	0.8	5	3.4	0.030 *
	Decreased	3	2.1	0	0.0	0	0.0	
	Increased	134	92.4	129	99.2	141	96.6	
Humidity	Unchanged	61	42.1	50	38.5	26	17.8	0.001**
	Decreased	8	5.5	3	2.3	5	3.4	
	Increased	76	52.4	77	59.2	115	78.8	
Heat stress	Unchanged	11	7.6	11	8.5	12	8.2	0.596NS
	Decreased	3	2.1	0	0.0	3	2.1	
	Increased	131	90.3	119	91.5	131	89.7	

humidity has been increased in compare to last decade, which cause insect and disease infestation.

Conclusion

Coastal agriculture is highly vulnerable to climate change and natural disasters. The intensity of disasters like sea level rise, tidal surge, soil salinity, salt water intrusion and cyclone in coastal belt are being increased. Long term meteorological data refers to the climatic variation on a specific area which would be very much helpful to determine the barriers of good agricultural production in that area. As this study is based on the secondary information about the climatic variation of Khulna and Pirojpur, more efficient evaluation can be performed with primary level information collected from the field to better understand the agricultural production with respect to the trend of climatic variation of that area.

Conflict of interest

There is no conflict of interest among the authors

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References

Alexandrov, V. A., & Hoogenboom, G. (2001). Climate variation and crop production in Georgia, USA, during the twentieth century. *Climate Research, 17*(1), 33-43.

BBS (Bangladesh Bureau of Statistics) (2011) Population and housing census report 2011. Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka

BCCAAP (Bangladesh Climate Change Strategy and Action Plan) (2010) Ministry of Environment and Forest (MOEF), Government of People's Republic of Bangladesh, Dhaka

BPRSP (Bangladesh: Poverty Reduction Strategy Paper) (2005). General economics division. Planning Commission, Government of People's Republic of Bangladesh, Dhaka

Climate Change and Water. Technical Paper of the Inter-Governmental Panel on Climate Change, IPCC Secretariat, Geneva, pp 210.

Fisher, M., Abate, T., Lunduka, R. W., Asnake, W., Alemayehu, Y., & Madulu, R. B. (2015). Drought tolerant maize for farmer adaptation to drought in sub-Saharan Africa: Determinants of adoption in eastern and southern Africa. *Climatic Change, 133*(2), 283-299.

Gilbert, R.O. (1987). Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold Company, Inc, New York.

Hollander, M., Wolfe, D.A. (1973). Nonparametric Statistical Methods. John Wiley and Sons, Inc., Hoboken, NJ.

Inter-governmental Panel on Climate Change (IPCC). (2007). Impacts, adaptation and vulnerability. Report of the working group-II.

IPCC. (2001) Climate change: Impacts, adaptation, and vulnerability, Cambridge: Cambridge University Press, 2001.

Kendall, M.G. (1975). Rank Correlation Methods. Charles Griffin and Co Ltd, London, U.K.

Mann, H.B., 1945. Non-parametric tests against trend. Econometrica 13, 245-259.

Meza-Pale, P., & Yunez-Naude, A. (2015). The Effect of Rainfall Variation on Agricultural Households: Evidence from Mexico.

Mohammad H. Mondal. (2005.) Challenges and Opportunities of sustainable crop production in Bangladesh. Eighth Biennial Agronomy Convention. Bangladesh Society of Agronomy.

Partal, T., Kahya, E. (2006). Trend analysis in Turkish precipitation data. Hydrol. Process. 20 (9), 2011-2026.

Poudel, S., & Shaw, R. (2016). The relationships between climate variability and crop yield in a Mountainous environment: A case study in Lamjung District, Nepal. *Climate*, *4*(1), 13.

Schlenker, W., & Roberts, M. J. (2008). Estimating the impact of climate change on crop yields: The importance of nonlinear temperature effects: National Bureau of Economic Research.

Wang, J., Huang, J., & Yang, J. (2014). Overview of impacts of climate change and adaptation in China's agriculture. *Journal of Integrative Agriculture*, *13*(1), 1-17.

Yilmaz, G., Perera, B.J.C. (2015). Spatiotemporal trend analysis of extreme rainfall events in Victoria, Australia. Water Resour. Manag. 29 (12), 4465-4480

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