Interdependency between Rainfall and Temperature using Correlation Analysis in the Barishal District of Bangladesh

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Introduction:

The climate of Bangladesh is changing and it is becoming more unpredictable every year. Global warming induced changes in temperature and rainfall are already evident in many parts of the world, as well as in our country. Hazards like floods, droughts, cyclones and others, which are aggravated by climate change and its variability being experienced more frequently in Bangladesh than ever before. Therefore, Bangladesh has given special emphasis on research works on location specific climate change and its impact analyses, particularly at district level for crops, livestock, and forestry. In Bangladesh the interest in climate-natural environment nexus is very much sustained. “Rainfall patterns show great fluctuations over the years and across vegetation zones. However there is gradual decrease in rainfall distribution in all parts of the country and this will affect agricultural production levels (Islam, 2019). Generally global temperatures are observed to be changing. The trend shows rising temperatures. The general outlook is that temperatures will continue to rise.

Background:

According to Owusu-Sekyere the onset of rainfall is presently starting late than previously and that annual rainfall is decreasing and temperature increasing. In fact, an accurate joint analysis of precipitation and temperature is more difficult to be carried out because of the possible interdependence between them. Nevertheless, Rajeevan et al. found that temperature and rainfall in India were positively correlated during January and May, but negatively correlated during July. Huang et al.showed a negative correlation between rainfall and temperature in the Yellow River basin of Chin. In addition, utilization of water by crops (e.g. maize) has been consistent over the years; various crops show yield decline as a result of the decreasing total annual rainfall or the increasing mean temperatures or both (Salman, 2020). Actually, Bangladesh crop farming is mainly rain-fed, crop productivity is highly dependent on rainfall which varies greatly over short distances, hence, it is important to use rainfall data from the site of interest. In this regard, the present paper examines local rainfall and temperature data in Barisal region for a period of 68 years. This analyses that follow show the correlation and regression between rainfall and temperature.

Materials and Methods:

The correlation analysis measures the degree of interdependence between two or more variables. It cannot prove a causal relationship, a relationship of cause and effect between variables. Interdependence can however be functional. By functional relationship we understand the relationship that can be expressed by a formula or by what mathematicians call a mathematics law, such as linear relationship formula. The fact that the two variables tend to be related, meaning that one of them increased levels tend to be accompanied by an increase of the second and vice versa, it doesn’t turn out that the first has a direct influence on the second or vice versa.

Determination of relationship between two variables raises the question: how close, how intense are these relationships and, consequently, how much can vary estimates or predictions made on the basis of regression analysis. As the average cannot be properly interpreted without a measure of the dispersion or variability of the data from which it resulted (and the most common measure is the average square deviation or standard deviation), so estimates or predictions resulting from the regression analysis require finding a measure of their variability. We will consider as measures of estimations variability based on.

Study Area:

The study area is situated in the most southern part of Bangladesh where Ganges-Brahmaputra-Meghna River system meets the Bay of Bengal. The study is only based on meteorological data (Rainfall, Maximum Temperature and Minimum Temperature) for the Barishal District of Bangladesh.

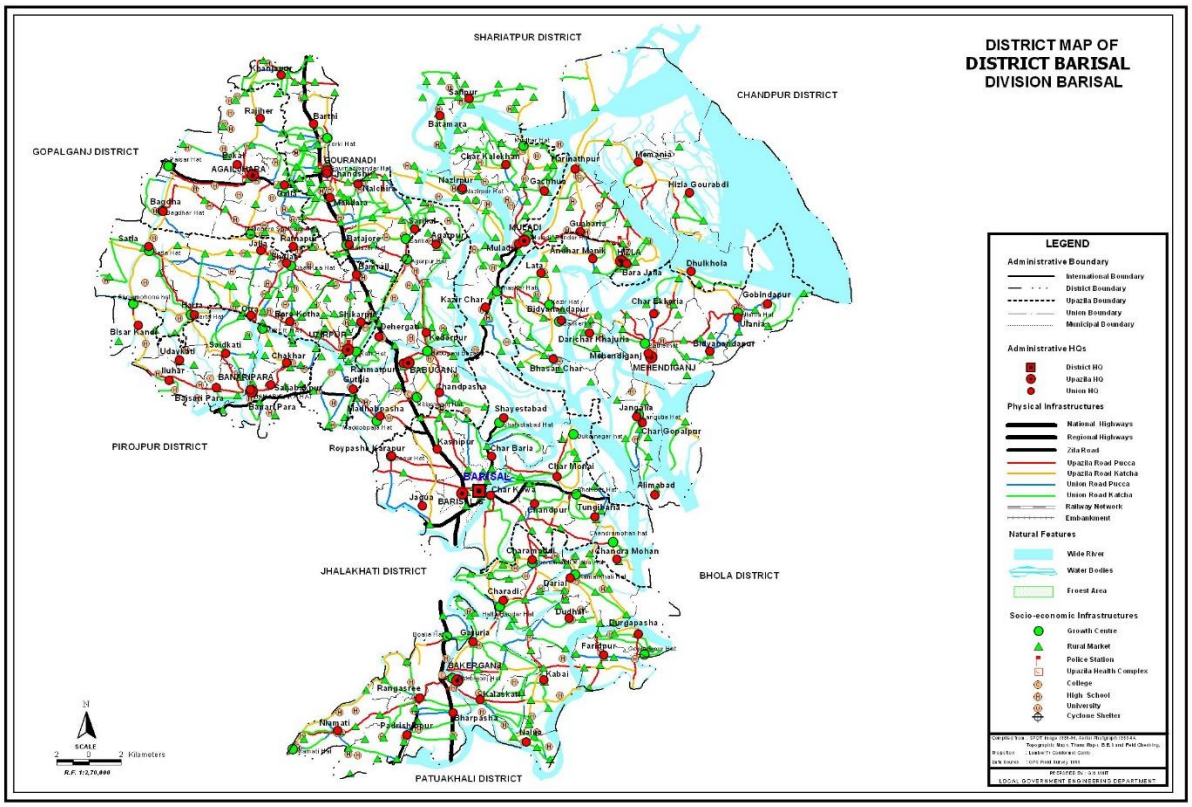

Figure 1Study Area and Location Of the Station in Barishal District

Data Collection and Preliminary Analysis:

Monthly maximum temperature, minimum temperature and rainfall data of Barishal district from 1949 to 2017 was obtained from the Bangladesh Meteorological Department (BMD). Graphs were produced with Microsoft Excel.

Result and Discussions:

The statistical approach here used to explore the relationships between climatic data series which are not perfectly similar, such as monthly rainfall and temperature, is the correlative analysis applied to the standardized anomalies. As first step, variability of average maximum temperature, minimum temperature and rainfall is listed in table.

Maximum Temperature: From the Table no 1, we see that the max. Temperature usually reaches its peak in April and its bottom in January; the average max. temperature is also peak in April and its bottom in January. The variability of average temperature in February and April is though relatively large. Some descriptive temperature statistics are listed in Table 1.

Max Temp.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Maximum	31.7	35.6	38.4	43.6	38.6	39.6	35.5	36.7	37.7	35.6	34	31.7
Minimum	26.7	29.2	33.4	32.5	33.5	32.2	31.9	31.4	32.2	32.3	29.4	26.6
Mean	28.9	32.14	35.69	36.36	35.95	35.23	33.75	34.15	34.42	34.06	32.09	29.19

Table 1Descriptive Statistics for Monthly Average Maximum Temperature from 1949 to 2017(C)

Minimum Temperature: From the Table No 2, we see that the min. temperature usually reaches its peak in August and its bottom in January; the average min. temperature is also peak in August and its bottom in January. The variability of average min. temperature in December and January is though relatively large.

Min. Temp.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Maximum	12.6	14.4	20	23.5	26	26.2	25.4	25.7	25.6	23.5	18.7	15.6
Minimum	6.4	7.2	12	15.8	17	19.2	17.4	21.6	21.5	12.7	11.9	7.5
Mean	9.388	11.081	15.558	19.734	20.931	23.022	24.036	24.18	23.7	20.6	15.4	11

Table 2: Descriptive Statistics for Monthly Average Minimum Temperature from 1949 to 2017(C)

Rainfall: From the Table No 3 we can say that June to September, the average monthly total rainfall is relatively high.

Rainfall	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Maximum	148	98	273	412	701	1025	785	823	1067	497	274	197
Minimum	0	0	0	0	22	139	185	138	90	6	0	0
Mean	8.89	19.65	46.01	96.93	208.17	408.64	424.76	356.61	301.5	189.1	42.8	8.77

Table 3: Descriptive Statistics for Monthly Average Rainfall from 1949 to 2017(mm)

The Relationship between Rainfall and Maximum Temperature: The physical rationale behind the relationship between rainfall and Maximum Temperature is that rainfall may affect soil moisture which may in turn affect surface temperature by controlling the partitioning between the sensible and latent heat fluxes. Because the sample data is non-Gaussian distributed and skewed, the Kendall correlation coefficient is employed to calculate the correlation between monthly

rainfall and maximum temperature. It is found that there are negative correlations between rainfall and maximum temperature from February to May and in August and December (at the 10% confidence level) (Table 4). In the Table No 4, we see that p value is greater than level of significance. So we can not reject the null hypothesis. Moreover, we can say that there is no statistically significant correlation between rainfall and maximum temperature.

	Jan.	Feb.	March	April	May	June	July	August	Sep.	Oct.	Nov.	Dec.
Kendall correlation coefficients	.180	-.106	-.051	-.083	-.018	.036	.088	-.147	.034	.012	.025	-.018
P value	.059	.234	.570	.352	.839	.680	.315	.090	.704	.896	.783	.854

Table 4: Correlation Analysis for monthly max temperature and rainfall from 1949 to 2017

The Relationship between Rainfall and Minimum Temperature: The physical rationale behind the relationship between rainfall and Minimum Temperature is that rainfall may affect soil moisture which may in turn affect surface temperature by controlling the partitioning between the sensible and latent heat fluxes. Because the sample data is non-Gaussian distributed and skewed, the Kendall correlation coefficient is employed to calculate the correlation between monthly rainfall and minimum temperature. It is found that there are negative correlations between rainfall and minimum temperature from September to December and in February and June also (at the 10% confidence level). In the Table 5, we see that p value is greater than level of significance. So we can not reject the null hypothesis. Moreover, we can say that there is no statistically significant correlation between rainfall and .minimum temperature.

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Kendall correlation coefficients	.056	-.051	.020	.022	.003	-.026	.137	.034	-.081	-.014	-.095	-.129
P value	.558	.566	.827	.802	.977	.771	.115	.701	.360	.873	.287	.188

Table 5: Correlation Analysis for monthly min temperature and rainfall from 1949 to 2017(mm)

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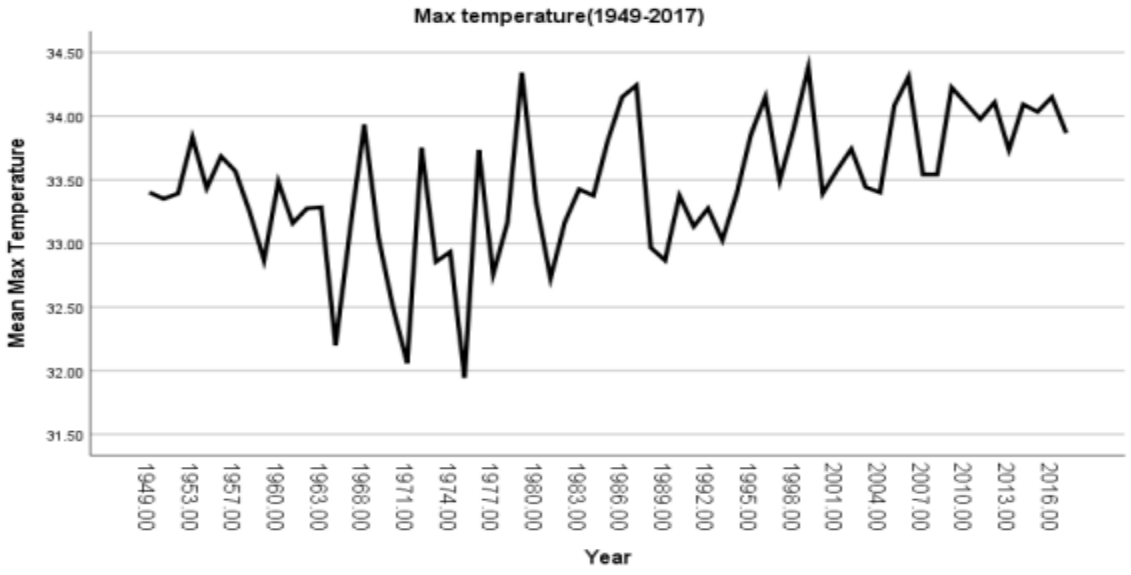

Figure 2: Maximum Temperature Graph for 1949-2017

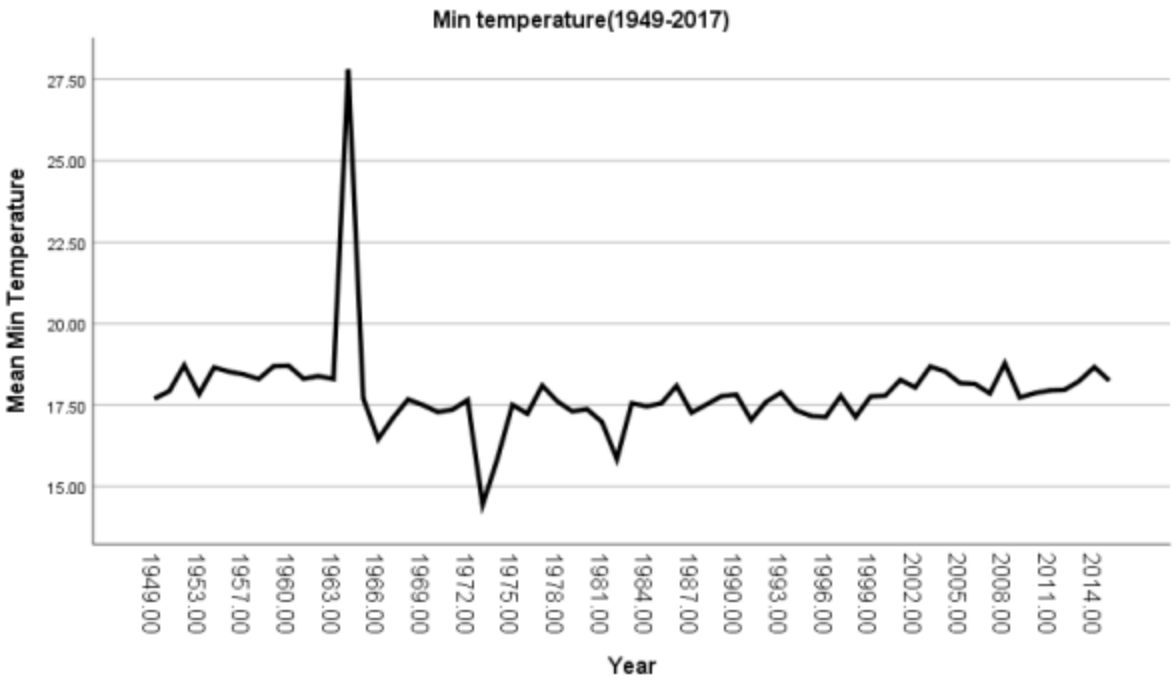

Figure 3: Minimum Temperature Graph for 1949 to 2017

Figure 3 reveals an ascending trend line for minimum temperature for 1949-2017. From the 68 years of data, the lowest mean minimum temperature occurred in 1973 (13°C) and the highest was recorded in 1965 (27.50 °C).

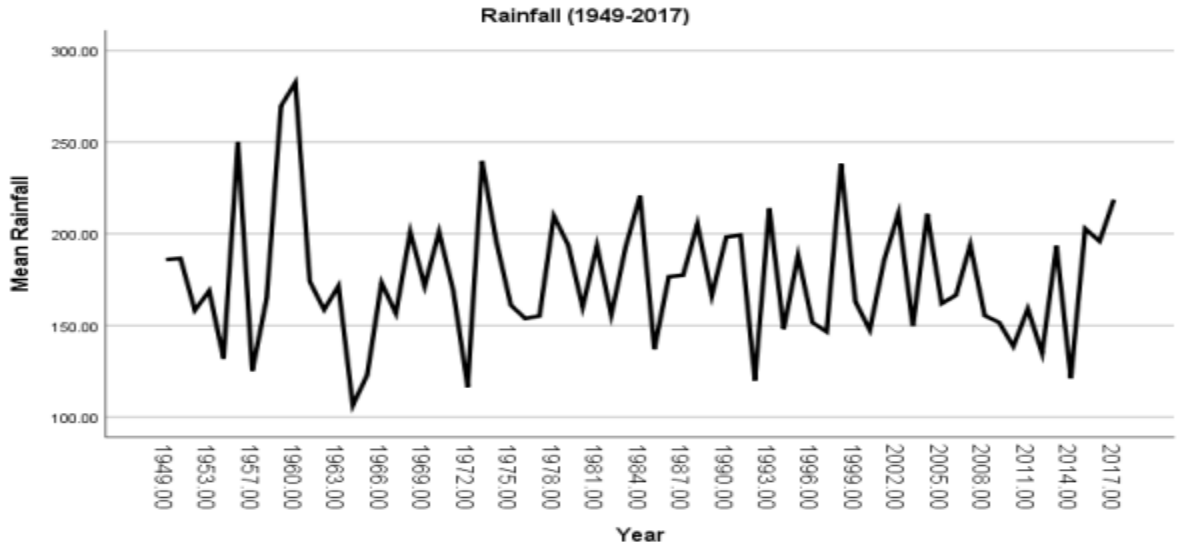

Figure 4: Rainfall Graph for 1949 to 2017

Figure 4 portrays trend of rainfall from 1949 to 2017. From the graph we can say that, highest mean rainfall was recorded in1960 (273mm) and lowest in 1963 (100mm).

Conclusion:

This paper presents a correlation analysis of temperature and rainfall, which are of utmost importance for agricultural production especially in the context of climate change. The main purpose of this paper is to present interdependence of rainfall and temperature in Barishal region, Bangladesh. The study is only based on meteorological data for a single region. A potentially valuable extension of this research is to connect the analysis with crop production planning and agricultural economics. If the relationship among temperature, rainfall, and crop yield can be determined, then it could be used in developing risk reducing strategies for farmers, something which will become increasingly important in the face of climate change. This is the focus of our ongoing research. From the analysis of 1949-2017 years of data, it has been found that annual rainfall range was 1277 mm – 3390 mm, maximum temperature was 32.2 °C – 43.6 °C and minimum temperature was 27.8 °C -5 °C. The highest mean maximum temperature was 34.50 °C and lowest mean maximum temperature was 32.00 °C. The lowest mean minimum temperature occurred in 1973 (13 °C) and the highest was recorded in 1965 (27.50 °C) where highest mean rainfall was recorded in1960 (273 mm) and lowest in 1963 (100 mm). Finally, The correlation between rainfall and temperature revealed that rainfall is not dependent on the variability of the temperature in Barishal region of Bangladesh.

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