

PRECIPITATION TREND ANALYSIS USING STATISTICAL AND GRAPHICAL APPROACH: A CASE STUDY AT THE SOUTHWESTERN COASTAL REGIONS IN BANGLADESH

Mst. Ahona Akter^{*1}, Samiha Siddiquee²

Student, Khulna University of Engineering & Technology, Bangladesh

***Corresponding Author**

ABSTRACT:

This study aims to identify rainfall trends and evaluate their significance in the southwestern coastal region of Bangladesh. Rainfall is an essential aspect of any watershed, playing a vital role in agriculture adaptation, food and waterlogging management, groundwater recharge, navigation and river transport, hydropower, and renewable energy potential. The study concentrates on recent variation in monthly and yearly precipitation at three stations of Barisal and Patuakhali. Rainfall records from 1981 to 2022 were sourced from NASA open data and data extraction was done in a Python program. To examine precipitation trends, both statistical and graphical methods were used, including the Mann–Kendall (MK) test with Sen’s Slope (SS) estimator for statistical analysis and the Innovative Trend Analysis (ITA) technique for graphical evaluation across the Barisal and Patuakhali regions. The findings are typically statistically significant at the 5% significance level. By applying the Mann–Kendall test and Sen’s Slope estimator, it indicates that rainfall in all three coastal districts is increasing significantly. This increase is particularly during the monsoon months (May–October). Annual totals show a strong positive trend, with Barisal showing the highest rates of increase, while Patuakhali exhibits a moderate but still significant increase. The ITA result is almost similar to the Mann–Kendall test, with both analyses indicating an overall increase in rainfall across all three regions. Barisal shows a moderate and stable rainfall increase with lower extremes, while Patuakhali experiences rapid rises, higher peaks, and greater variability. Minimal precipitation is observed from January to April and November to December, indicating possible drought conditions in these months. The ITA method is more effective at detecting trends because it does not assume any assumptions like the MK test. Overall, the findings highlight the increasing rainfall trends and seasonal variability in southern Bangladesh, providing crucial insights for effective water resource management, rainwater harvesting, agricultural planning, and climate adaptation strategies in the region.

Keywords: Precipitation; Southwestern coastal region; Mann–Kendall test; Sen’s Slope estimator; Innovative Trend Analysis.

1. INTRODUCTION

Climate change stands as one of the foremost environmental challenges of the present age, capturing the attention of governments, scientists, and global communities alike. It is defined by the Intergovernmental panel on climatic change (IPCC) as long-term change in climatic system, which manifests itself in the long-lasting changes in the mean state or variability of climatic properties that are sustained over a period of decades or more (Bari et al., 2016; Salman & Ahmed, 2020). Bangladesh is ranked among the most climate-prone countries based on a set of hydrogeologic and socio-economic circumstances. It is particularly sensitive to environmental hazards by virtue of its geographical location in South Asia, great volatility of climate as a result of the monsoon winds, and low-lying topography as a delta (Ali et al., 2025; Khan et al., 2019; Salman & Ahmed, 2020). Moreover, a significant percentage of the population relies on agriculture which is very sensitive to changes in rainfall and temperature, and the high population density and poverty experienced in the country make it even more prone.

Bangladesh is considered to be among the countries that are most vulnerable to climate change (IPCC, 2013). The number of natural disasters like rising temperatures, floods, cyclones, droughts, saline water intrusion, sea-level rise, and heavy monsoon downpours is high and offers a massive social and economic disruption (Ahmed & Karmakar, 1993). The economic system of the country, especially its farming and industry, depends on good climatic conditions. The monsoon towards the southwest prevails in Bangladesh and most of the seasonal rainfall, crop yield, and general farming output are greatly influenced by it.

Barisal, located in the south-central coastal zone of Bangladesh, exemplifies the nation's high exposure to climatic hazards (Khan et al., 2019). The rate of precipitation in Barisal is vital in understanding the hydrological balance of the area and agricultural performance, as well as vulnerability to climate change. Being a part of the Ganges-Brahmaputra-Meghna delta, the economy and livelihoods of Barisal are directly dependent on rainfall, which supports crop planting, fisheries, and freshwater. Any change in the precaution will influence the soil fertility, irrigation needs, and flood intensity- factors that directly influence the food security and income earned in rural regions (Alam et al., 2023; Kamruzzaman et al., 2019). Extreme events of weather, including droughts, severe monsoon floods, etc., are also essential to detect changes in the occurrence of this phenomenon with a changing climate due to extended rainfall (Ahmed & Kim, 2003; Zena Besha et al., 2022). It is estimated that USD 10 million is lost by the communities of Barisal every year due to floods and cyclones, and this amount is expected to increase dramatically by 2050. With a middle growth and climate description, the cumulative climate-related expenses may end up totalling around USD 130 million per annum by the middle of the century (Salman & Ahmed, 2020). As a result, proper understanding of how precipitation behaves is important to policymakers and planners so that in their endeavour to come up with effective water management systems, they develop better disaster preparedness and sustainable development in the area.

Various researchers around the world have conducted research to understand the effects of climate change and ways it can be reduced to bring the negative effects to a minimum. Nevertheless, Bangladesh continues to be behind in the establishment of in-depth research and adjustment plans on the same. Despite the fact that a number of studies have been done to analyze rainfall variability in certain areas of the country (Ahmed & Kim, 2003; Ali et al., 2025; Hamed, 2008a; Khan et al., 2019), none of them has conducted a comprehensive analysis of the major climatic variables in the whole country. The majority of the research work has been inclined to narrow parameters, and there are gaps in the knowledge about wider interactions of climatic interactions. Non-parametric techniques like the

The countrywide studies have found out that post-monsoon rainfall decreases ((Güçlü, 2018)) and in the northeast, temperatures were rising, with uneven rainfall patterns (Mann, 1945). There was an improvement in the rainfall and temperature in Dhaka per year (Agbo et al., 2023; Hossen & Evan, 2023). India and Turkey studies of a similar nature affirmed that there were regional differences in rainfall and temperatures (Gupta & Verma, 2023). The results demonstrate the usefulness of MK, Sen slope, and ITA in identifying climatic variation and as such, they should be used in the study of the precipitation at Barisal.

A test for serial correlation was conducted at first in the study, but for serially dependent time series, any Mann Kendall trend test was not utilized, which could produce erroneous results. Besides, the majority of the studies examined seasonal differences without dwelling upon long-term annual trends. In order to overcome these shortcomings, the current paper uses both the Mann-Kendall and modified Mann-Kendall tests and Sen slope estimator to test time series changes in correlated and uncorrelated climatic variables. The study places emphasis on rainfall variability and anomalies, which play a crucial role in determining Barisal's long-term agricultural output and adaptive capacity to climate change.

2. METHODOLOGY:

The current study investigates statistical trends associated with climate change in the southwestern coastal area of Bangladesh. Precipitation exhibits significant variability in the southwestern coastal region of Bangladesh. The study concentrates on two meteorological stations—Barisal and Patuakhali chosen and at least 42 years of rainfall data are collected from NASA power data.

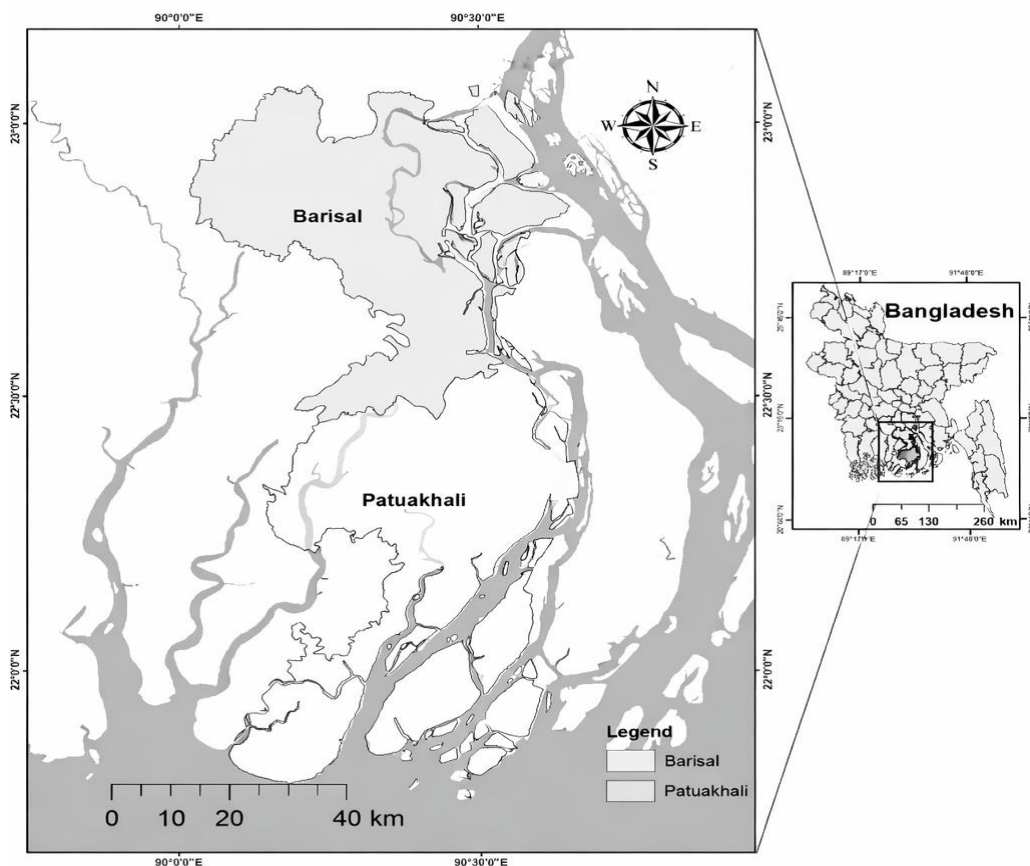


Figure 1: Study area map of Barisal division

Climate records, spanning from 1981 to 2022, are analyzed for these locations. In the current research, the precipitation trend is assessed using three different methods. Firstly, the statistical (MK test) is applied to detect the presence of rising or falling trends. After that, to find the proper slope of a linear trend, the SS estimator test is used. Lastly, a graphical method (ITA) is adopted to find trends in precipitation data with or without considering the effects of autocorrelation, size of the dataset, and distributions. Figure 2 shows the outline of the methodology adopted for the analysis. (Patel & Mehta, 2023)

2.1 The Study Area and Data Collection

Barisal District (Barisal division) has an area of 2784.52 sq. km, located between 22°27' and 22°52' north latitudes and between 90°01' and 90°43' east longitudes. It is bounded by Madaripur, Shariatpur, and Chandpur districts on the north; Patuakhali, Barguna, and Jhalokati districts on the south; Bhola and Lakshmipur districts on the east; Jhalokati, Pirojpur, and Gopalganj districts on the west. Total population 2324310 (Bangladesh Population Census 2001 and 2011, Bangladesh Bureau of Statistics; Cultural survey report of Barisal District 2007; Cultural survey report of the Upazilas under Barisal District 2007). This study focuses on three coastal districts: Barisal and Patuakhali (Figure 1). These districts are located along the lower Meghna estuary and the Bay of Bengal, making them highly vulnerable to the impacts of climate change. The region is characterized by a tropical monsoon climate with hot, humid summers and mild winters, where rainfall plays a vital role in agriculture, fisheries, and livelihoods. (Salman & Ahmed, 2020)

For this study, monthly and annual precipitation data covering 42 years (1981–2022) were obtained from NASA POWER satellite products. Table 1 displays the information about those stations.

Table 1: Location and characteristics of meteorological stations considered in this study.

Serial No.	Station Name	Latitude (N)	Longitude (E)	Elevation from MERRA-2 (m)	Data Period
1	Barisal	22°42'0"	90°22'0"	9 m	1981-2022
2	Patuakhali	22°21'31"	90°19'54"	6 m	1981-2022

2.2 Testing Autocorrelation

Autocorrelation constitutes a critical issue in the trend analysis of precipitation time series. The presence of either positive or negative autocorrelation leads to biased and underestimated trend outcomes (Ahmed & Kim, 2003; Hamed, 2008a). Moreover, in cases where no actual trend exists, non-parametric tests may incorrectly identify a significant trend under positive autocorrelation or fail to detect a true trend under negative autocorrelation. Hence, it is imperative to address and eliminate autocorrelation prior to conducting trend analysis (Patel & Mehta, 2023). To assess its presence, the lag-1 autocorrelation coefficient (r_1) is computed at a 5% significance level using the following equation.

$$r_1 = \frac{\frac{1}{n-1} \sum_{i=1}^{n-1} [x_i - E(x_i)] \times [x_{(i+1)} - E(x_i)]}{\frac{1}{n} \sum_{i=1}^n (x_i - E(x_i))^2} \quad (1)$$

$$\sum(x_i) = \frac{1}{n} \sum_{i=1}^n x_i \quad (2)$$

Where $\sum(x_i)$ represents the mean of sample data and n denotes the sample size.

To determine the presence of autocorrelation, r_1 is evaluated at a 95% confidence interval using the following equation.

$$r_1 [95\%] = \frac{-1 \pm 1.96\sqrt{n-2}}{n-1} \quad (3)$$

2.2.1 Mann-Kendal Trend Test:

In Mann-Kendall trend test (Hamed, 2008b; Mann, 1945) the data are estimated as an ordered time series. It is a statistical test (non-parametric rank-based) and usually applied to discover trends in the precipitation time series, whether it is linear or not (Agbo et al., 2023). The initial value of the Mann-Kendall statistic S is assumed to be 0 (no trend). The Mann Kendall statistics S is given as follows-

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^n \text{sign}(x_j - x_i) \quad (4)$$

If $x_1, x_2, x_3, \dots, x_n$ represent n data points where x_i represents the data point at time i . where x_i and x_j represent precipitation time series data (years) and n represents the length of data.

$$\text{sign}(x_j - x_i) = \begin{cases} -1, (x_j - x_i) > 0 \\ 0, (x_j - x_i) = 0 \\ +1, (x_j - x_i) < 0 \end{cases} \quad (5)$$

To calculate the variance, the following equation is used -

$$\text{Var}(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^k t_i i(i-1)(2i+5)}{18} \quad (6)$$

Where, t means the number of observations. The following equation is applied to determine the standard statistic (Z_{MK}) value:

$$Z_{MK} = \begin{cases} \frac{S+1}{\sqrt{\text{Var}(S)}}, \text{ if } S < 0 \\ 0, \text{ if } S = 0 \\ \frac{S-1}{\sqrt{\text{Var}(S)}}, \text{ if } S > 0 \end{cases} \quad (7)$$

To determine whether a significant trend is present or not, the predicted Z_{MK} value is compared to a typical normal distribution using two-tailed significant levels. The null hypothesis (H_0) is accepted at a 5% significant level. There is an increasing or positive trend in the data, if the value of Z_{MK} is more than zero ($Z_{MK} > 0$). Similarly, when the Z_{MK} value is less than zero ($Z_{MK} < 0$), it shows a decreasing or negative trend exists in the data. However, if Z_{MK} is equal to zero ($Z_{MK} = 0$), the trend is interpreted as no trend.

2.2.2 Sen's Slope Estimator Test:

The MK test cannot determine the magnitude of trend variation. Therefore, the Sen's Slope estimator developed by Sen's (1968) is used to determine the rate of change or slope of the linear trend in the precipitation data (Prodhan et al., 2024).

It can be calculated using the following equation:

$$\beta_i = \text{median} \frac{x_i - x_j}{(i - j)}, j < i \quad (8)$$

Where β_i means slope, x means variables, i and j are indices. If $\beta_i > 0$ it indicates upward trends in a time series data. Otherwise, the data series shows a downward trend during the period, when $\beta_i < 0$.

2.2.3 Innovative Trend Analysis:

Innovative Trend Analysis (ITA) is a non-parametric graphical method that was employed to identify monotonic trends in hydro-climatic time-series, which involves splitting the data on even halves and ranking the two sets of data separately and then comparing them (Şen, 2012). A 1:1 line is a line whose data above the line show an increasing trend and a decreasing trend, respectively. ITA is particularly effective for climate variables that exhibit disruptiveness, short data records, and autocorrelation, conditions under which classical trend tests may lose reliability (Patel & Mehta, 2023). Compared to MK-based approaches, ITA demonstrates greater resilience to serial correlation and skewed distributions, making it useful for hydrological trend assessment under climate variability.

3. RESULTS & DISCUSSION:

The analysis of rainfall trends arise abrupt changes found in Bangladesh over the time period 1981–2022. The obtained outcomes are described in the following sections. The trend analysis of the precipitation data has been done using the data of precipitation of Barisal and Patuakhali stations.

Table 2: Mann-Kendall test data for Barisal

Period	Kendall Tau	p-value	Sen Slope	Trend	Significant
JAN	0.003221	0.975711	0	Increasing	No
FEB	0.052854	0.613058	0.0508	Increasing	No
MAR	0.145877	0.162784	0.404559	Increasing	No
APR	0.040169	0.700725	0.194779	Increasing	No
MAY	0.389006	0.000198	5.825364	Increasing	Yes
JUN	0.498943	1.81E-06	10.06074	Increasing	Yes
JUL	0.424947	4.78E-05	11.10932	Increasing	Yes

AUG	0.587738	1.87E-08	12.85136	Increasing	Yes
SEP	0.545455	1.80E-07	8.857604	Increasing	Yes
OCT	0.560254	8.30E-08	7.845427	Increasing	Yes
NOV	0.160847	0.124165	0.375439	Increasing	No
DEC	0.106499	0.311284	0.012154	Increasing	No
ANN	0.610994	5.03E-09	61.07738	Increasing	Yes

The Mann–Kendall (MK) test and Sen’s slope estimator were applied to evaluate precipitation trends in Barisal. The findings suggest that the pattern shows the steady rising trend of all months of the year and on the annual basis though the statistical significance varies seasonally. During January–April, precipitation trends are positive but statistically insignificant ($p > 0.05$), implying minimal long-term change. A significant increasing trend emerges in May ($\tau = 0.389$, $p = 0.000198$), marking an early intensification of pre-monsoon rainfall. The upward trends in the monsoon months (June- October) are strong and significant ($p < 0.05$) with Sen’s slope values ranging between 7.84 and 12.85 mm/year and this shows that there are very great changes in the intensity of the rainfall. The most pronounced rise occurs in August (Sen’s slope = 12.85 mm/year). Conversely, November–December show weak, non-significant increases. On an annual scale, precipitation demonstrates a highly significant increasing trend ($\tau = 0.611$, $p = 5.03 \times 10^{-9}$) with a Sen’s slope of 61.08 mm/year. These results indicate that there is a net increase in rainfall especially during the monsoon season and this could affect the hydrology of the region, flood cycles and farming plans in southern Bangladesh.

Table 3: Mann-Kendall test data for Patuakhali

Period	Kendall Tau	p-value	Sen Slope	Trend	Significant
JAN	0.005416	0.959407	0	Increasing	No
FEB	0.042283	0.685793	0.031214	Increasing	No
MAR	0.099366	0.341736	0.201429	Increasing	No
APR	0.040169	0.700725	0.223889	Increasing	No
MAY	0.353066	0.00073	4.333268	Increasing	Yes
JUN	0.372093	0.000371	5.488986	Increasing	Yes
JUL	0.418605	6.20E-05	7.769686	Increasing	Yes
AUG	0.547569	1.61E-07	9.009697	Increasing	Yes
SEP	0.539112	2.49E-07	7.353703	Increasing	Yes
OCT	0.490486	2.69E-06	7.071274	Increasing	Yes

NOV	0.152543	0.145171	0.305513	Increasing	No
DEC	0.114633	0.277944	0.02625	Increasing	No
ANN	0.589852	1.66E-08	45.92491	Increasing	Yes

In the dry months (January-April), rainfall trends remain positive but statistically insignificant ($p > 0.05$), hence there are slight variations in precipitation during the early seasons. The major positive trend starts in May ($\tau = 0.353$, $p = 0.00073$), when the strengthening of the pre-monsoon rainfall starts. The monsoon months (June-October) have shown very high increasing trends ($p < 0.05$) with the values of Sen's slope between 5.49 to 9.01 mm/year indicating that rainfall is increasing substantially in the wet months. August has been found to have the greatest increase (Sen's slope = 9.01 mm/year). The post-monsoon period (November–December) exhibits weak, non-significant increases, reflecting stable precipitation toward the year's end. On the annual scale, the increasing trend of rainfall is highly significant ($\tau = 0.5899$, $p = 1.66 \times 10^{-8}$) at a Sen's slope of 45.92 mm/year, which allows confirming a steady increase in the overall yearly rainfall. These findings suggest that intense monsoonal rainfall in Patuakhali is increasing, and this can increase the risk of floods and impact the regional water resources management in the coastal areas in Bangladesh.

3.1 Graphical Analysis of Precipitation Trends Using the ITA Method:

Innovative Trend Analysis (ITA) was used to assess the temporal change as the time series of precipitation was divided into two equal parts and compared in terms of their behaviour. Figures 2 and 3 indicate the pre-monsoon, SW (southwest), post-monsoon, and winter seasonal ITA results in Barishal and Patuakhali, and Figure 4 depicts the annual precipitation rates in the two areas. The 1:1 line in the dashed form in each panel is the equality line or the place where the value of the earlier period and the later period are equal and hence represent the existence of no trend. The data points on this line indicate stable conditions whereas the data points above and below indicate increasing and decreasing trends respectively. The scale of adjustment is gained upon the dispensation of the points along the 1:1 line; the greater the deviation the greater the trends. In all seasons and at the annual level the most observations are above the equality line indicating general increase in rainfall. The highest growth is recorded during the SW monsoon season with almost 1200 mm in Barishal and over 800 mm in Patuakhali which reflects the increase in recent monsoonal rainfall. The pre-monsoon and post-monsoon periods show the moderate upward trends as well with winter rainfall showing relatively weak yet consistent increase. Altogether, the ITA outcomes in Figures 2-4 indicate a steady increase in seasonal and annual silage in the area of interest, where the changes are the most notable during the SW monsoon season.

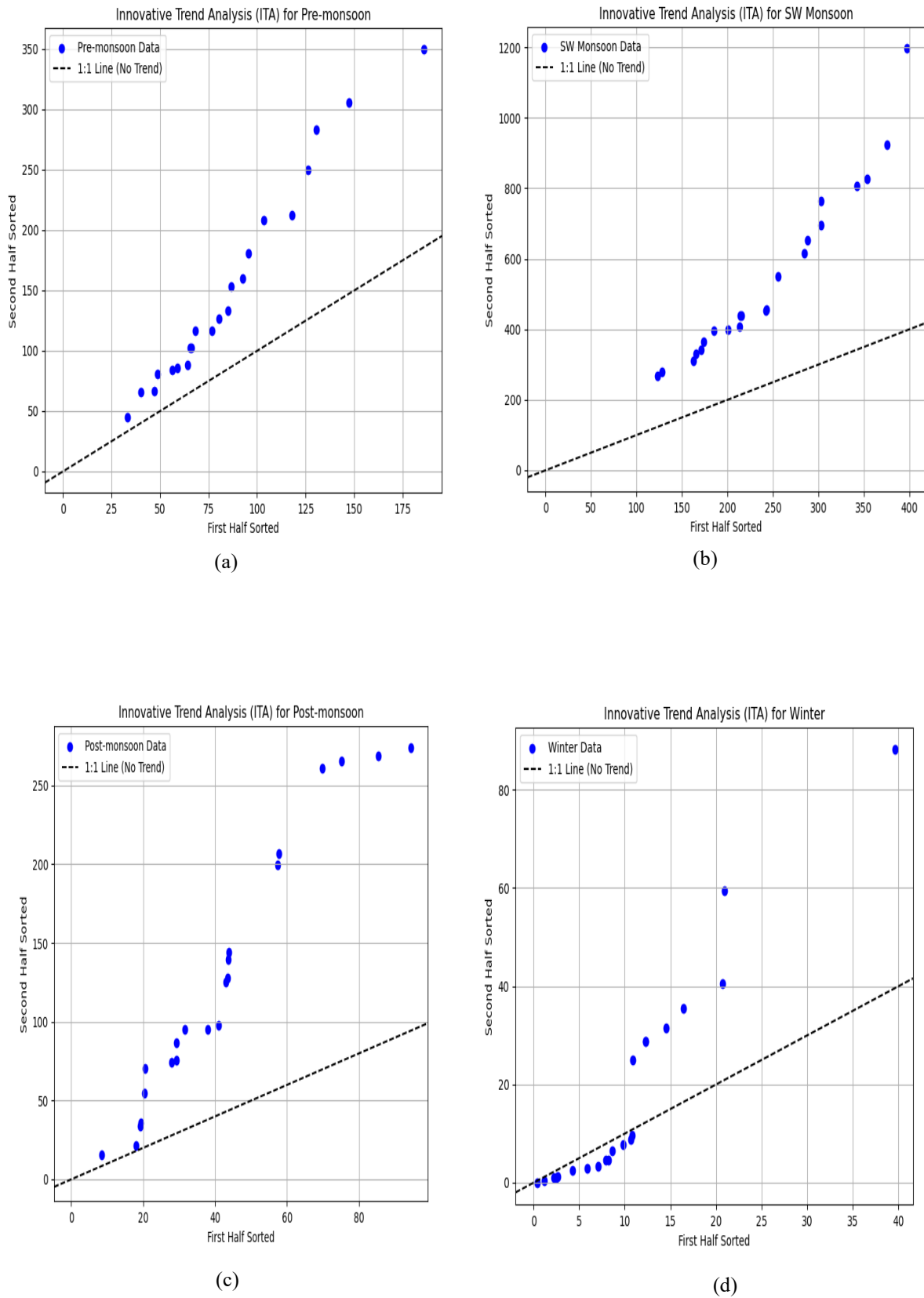
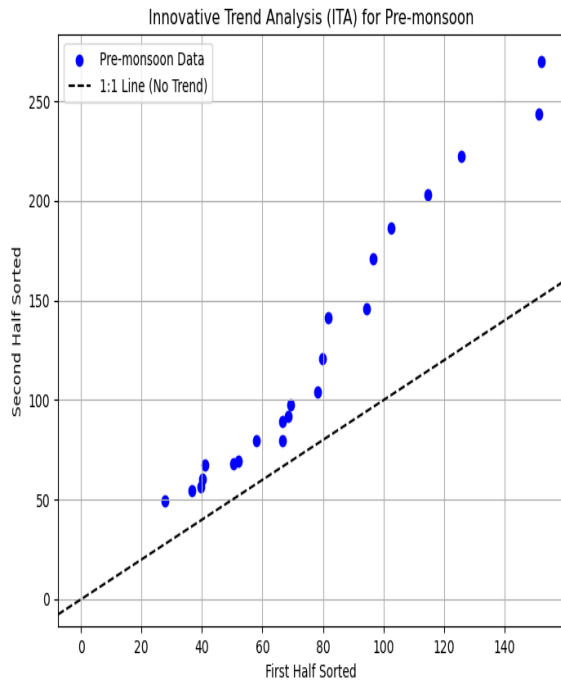
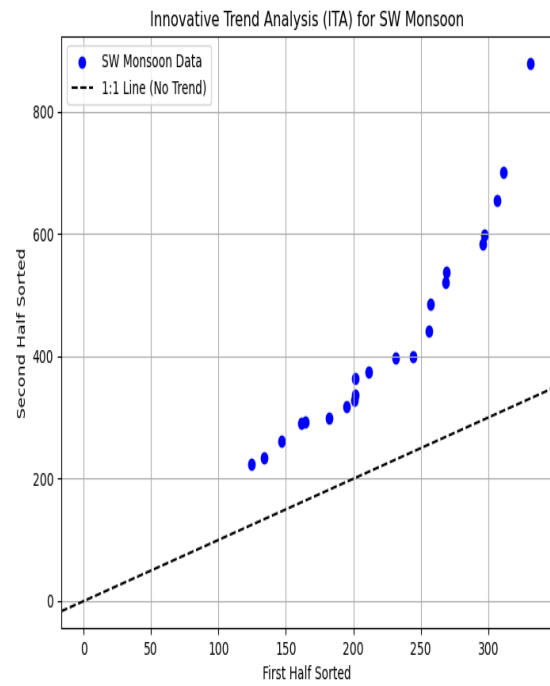


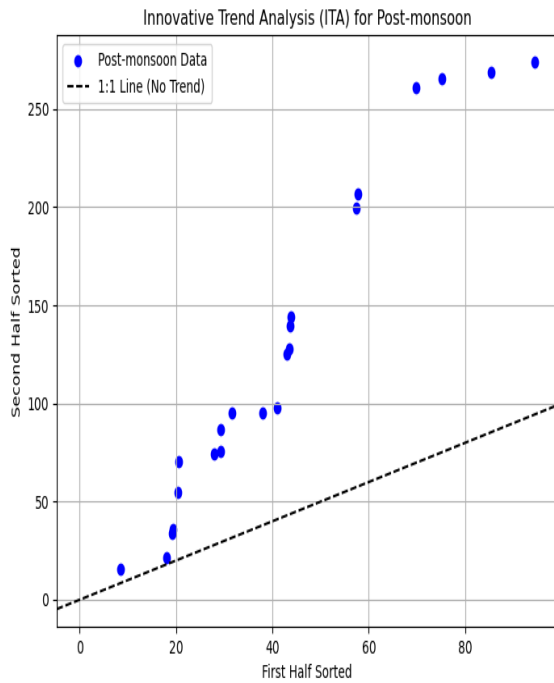
Figure 2: Seasonal precipitation trend analysis for Barisal (a) ITA for pre-monsoon, (b) ITA for SW-monsoon, (c) ITA for post-monsoon, (d) ITA for winter



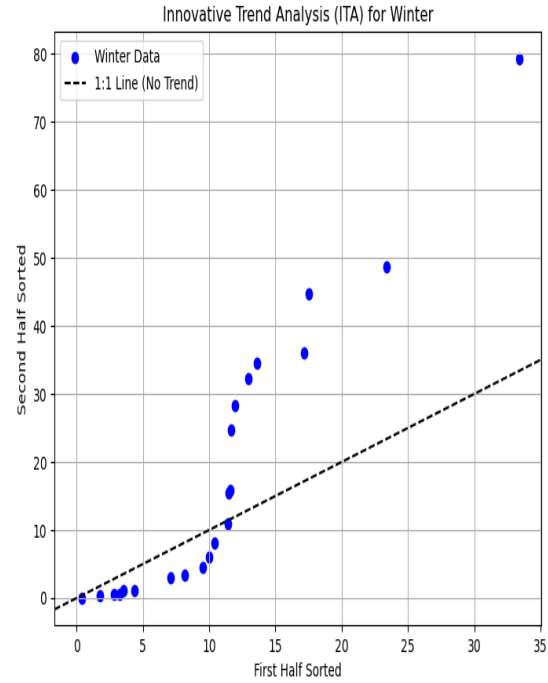
(e)



(f)



(g)



(h)

Figure 3: Seasonal precipitation trend analysis for Patuakhali (a) ITA for pre-monsoon, (b) ITA for SW-monsoon, (c) ITA for post-monsoon, (d) ITA for winter

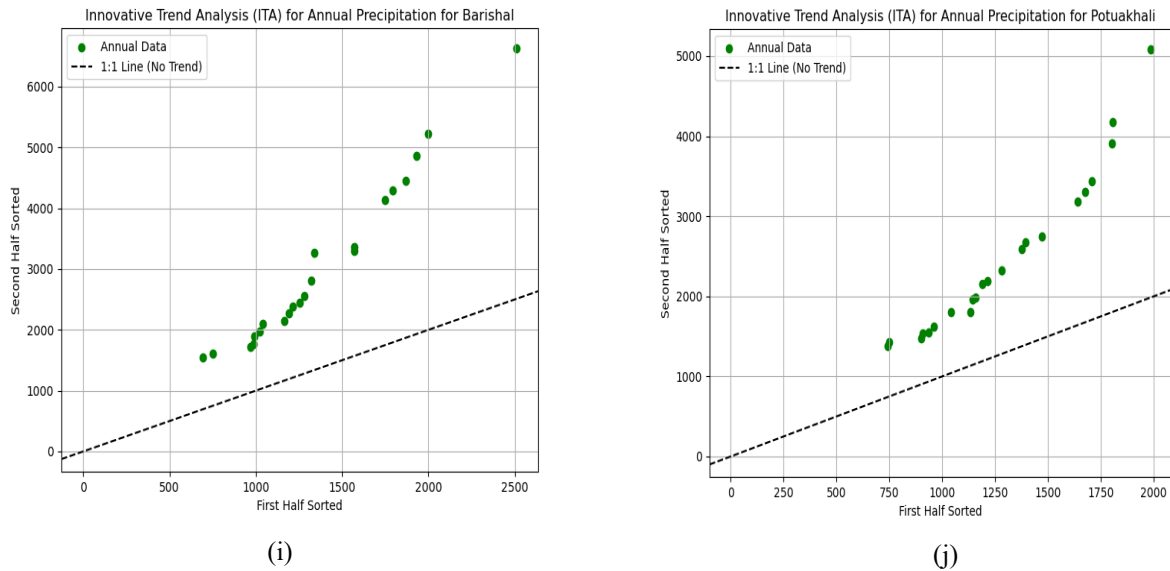


Figure 4: Annual precipitation trend analysis using the ITA method for (i) Barishal, (j) Patuakhali

4. CONCLUSION:

This paper examined the long-term precipitation trends of the southwestern coastal area in Bangladesh, i.e., Barisal and Patuakhali, in terms of both statistical (Mann Kendall and Sen's Slope) and graphical (Innovative Trend Analysis, ITA) methods during 1981-2022. The slope tests by Mann-Kendall and Sen showed that annual and monsoon rainfall is positively increasing and at a steady rate, especially during the months of May to October which is a sign of high monsoon activity in the past few decades. These findings were further supported by the ITA results with the majority of data points above the 1:1 line indicating an overall upward trend in rainfall of all seasons. Spatial differences between rainfall intensification in the region as seen in Barisal and Patuakhali indicated that in Barisal there was a stronger increase in precipitation than in Patuakhali. This increase in rainfall is important to the agriculture-based economy of the Barisal Division, but it has also increased flooding, road damage, and deterioration of infrastructure. In general, the results indicate a gradual change to a more humid environment in the coastal areas of Bangladesh and emphasize the necessity of changing the way the water resources are managed and agricultural systems have to be climate resilient to address the possible effects of changing precipitation patterns. The future study should focus on enhancing the accuracy of data by including various data sources and increase the observation stations within the Barisal Division.

Declaration of Use of AI

The authors used AI-based tools to improve grammar, sentence structure, and overall language clarity of the manuscript.

REFERENCES:

- Agbo, E. P., Nkajoe, U., & Edet, C. O. (2023). Comparison of Mann-Kendall and Sen's innovative trend method for climatic parameters over Nigeria's climatic zones. *Climate Dynamics*, 60(11-12), 3385-3401. <https://doi.org/10.1007/s00382-022-06521-9>
- Ahmed, R., & Karmakar, S. (1993). Arrival and withdrawal dates of the summer monsoon in Bangladesh. *International Journal of Climatology*, 13(7), 727-740. <https://doi.org/10.1002/joc.3370130703>

- Ahmed, R., & Kim, I.-K. (2003). Patterns of Daily Rainfall in Bangladesh During the Summer Monsoon Season: Case Studies at Three Stations. *Physical Geography*, 24(4), 295–318. <https://doi.org/10.2747/0272-3646.24.4.295>
- Alam, E., Hridoy, A.-E. E., Tusher, S. Md. S. H., Islam, A. R. Md. T., & Islam, M. K. (2023). Climate change in Bangladesh: Temperature and rainfall climatology of Bangladesh for 1949–2013 and its implication on rice yield. *PLOS ONE*, 18(10), e0292668. <https://doi.org/10.1371/journal.pone.0292668>
- Ali, M., Amin, M. K., & Hasan, G. M. J. (2025). Analysis of rainfall patterns and modulations of extreme climatic indices along the coastal zones of Bangladesh. *Journal of Earth System Science*, 134(3), 145. <https://doi.org/10.1007/s12040-025-02603-4>
- Bari, S. H., Rahman, M. T. U., Hoque, M. A., & Hussain, Md. M. (2016). Analysis of seasonal and annual rainfall trends in the northern region of Bangladesh. *Atmospheric Research*, 176–177, 148–158. <https://doi.org/10.1016/j.atmosres.2016.02.008>
- Hamed, K. H. (2008a). Trend detection in hydrologic data: The Mann–Kendall trend test under the scaling hypothesis. *Journal of Hydrology*, 349(3–4), 350–363. <https://doi.org/10.1016/j.jhydrol.2007.11.009>
- Kamruzzaman, M., Jang, M.-W., Cho, J., & Hwang, S. (2019). Future Changes in Precipitation and Drought Characteristics over Bangladesh under CMIP5 Climatological Projections. *Water*, 11(11), 2219. <https://doi.org/10.3390/w11112219>
- Khan, M. H. R., Rahman, A., Luo, C., Kumar, S., Islam, G. M. A., & Hossain, M. A. (2019). Detection of changes and trends in climatic variables in Bangladesh during 1988–2017. *Heliyon*, 5(3), e01268. <https://doi.org/10.1016/j.heliyon.2019.e01268>
- Mann, H. B. (1945). Nonparametric Tests Against Trend. *Econometrica*, 13(3), 245. <https://doi.org/10.2307/1907187>
- Patel, S., & Mehta, D. (2023). Statistical analysis of climate change over Hanumangarh district. *Journal of Water and Climate Change*, 14(6), 2029–2041. <https://doi.org/10.2166/wcc.2023.227>
- Prodhan, M. M. H., Islam, Md. B., & Rahman, S. M. (2024). *Temporal Variations of Rainfall and Temperature in Northwestern Bangladesh Using Mann-Kendall Trend Test*. In Review. <https://doi.org/10.21203/rs.3.rs-3928076/v1>
- Salman, M. A., & Ahmed, F. (2020). CLIMATOLOGY IN BARISHAL, BANGLADESH: A HISTORICAL ANALYSIS OF TEMPERATURE, RAINFALL, WIND SPEED AND RELATIVE HUMIDITY DATA. *Malaysian Journal of Geosciences*, 4(1), 43–53. <https://doi.org/10.26480/mjg.01.2020.43.53>
- Şen, Z. (2012). Innovative Trend Analysis Methodology. *Journal of Hydrologic Engineering*, 17(9), 1042–1046. [https://doi.org/10.1061/\(ASCE\)HE.1943-5584.0000556](https://doi.org/10.1061/(ASCE)HE.1943-5584.0000556)
- Gupta, L. K., & Verma, S. (2023). Rainfall and Temperature Trend Analysis Using Mann-Kendall and Sen's Slope Estimator Test in Kharun Watershed, Chhattisgarh, India. *Current Journal of Applied Science and Technology*, 42(23), 1–9. <https://doi.org/10.9734/cjast/2023/v42i234174>