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RESEARCH ARTICLE

A Trend Analysis of Climatic Variables in the Karimganj District of Assam, India

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Abstract

Objectives: The main goal of this research is to analyse the trends of climatic variables in the Karimganj district of Assam. The study examines the trend of seasonal and annual temperature maximum, temperature minimum, rainfall and relative humidity for the period 1981-2020. **Methods:** A non-parametric Mann-Kendall (MK) technique has been employed to establish statistically significant trend in the series. The magnitude of a time series trend has been evaluated by Sen's slope test. Trend lines and time series graphs are used for better understanding of trends. **Findings:** It has been found that annual and seasonal temperature maximum (Tmax) have a significant negative trend over the period except post monsoon season. There is no significant trend in the annual temperature minimum (Tmin) series but seasonal mean temperature minimum is showing a significant positive trend at different levels of significance during all four seasons. Except winter season, annual rainfall series and all other seasonal average rainfall series are showing significant positive trends. The seasonal averages and annual relative humidity are showing statistically significant positive trends over the period. **Novelty:** The study is unique and innovative for Karimganj district of Assam to best of our knowledge. From the analysis, the study claims that climate change is occurring in the district. To combat the impact of climate change, participation of people in adaptations practices and government intervention in the form of mitigation policies are necessary.

JEL Classification: Q50, Q54

Keywords: Karimgani; climate change; rainfall; temperature; relative humidity; Assam

1 Introduction

Climate change has caused changes to environmental and socioeconomic system not just in India, but also in other parts of the world. Global warming as a result of climate change is the newest and most talked-about topic in today's globe, since it represents the most serious threat to life on the earth. Assam is the largest agrarian state among North-East India and climate variability has already been noticed in Assam, with irregular monsoons, frequent floods, drought-like conditions, and a hotter winter [1]. According to a recent assessment by the Indian government's Department of Science and Technology (DST), Assam is one of the country's most susceptible states to climate change with a vulnerability index of 0.620[2]. As per district level vulnerability indices, Karimganj is the highest vulnerable district to climate change among all Indian districts with vulnerability indices 0.753[2]. The district is situated between the longitudes of 92°15' and 92°35' east and the latitudes of 24°15' and 25°55' north. It is an important topic to analyse the trends of climatic variables for Karimganj district which is a unique and innovative study to the best of our knowledge.

Rainfall and temperature are the two most influential variables in climate and hydrology research, since they influence the environmental elements that affect agricultural output in a certain location[3]. Other environmental factors, including humidity and wind speed are also important. As a result, leaving such variables out of the analysis is likely to bias the projected effects of climate change[4]. Non-linear dynamics of all these variables have not been assessed simultaneously at the regional scale in Assam. Therefore, this study explores the trends of relative humidity along with temperature and rainfall.

The primary objective of this study is to look at the trends of climatic variables in the Karimganj district of Assam.

2 Literature Survey

Some recent research works have been reviewed which are very relevant to this study. A research work exposed that the Monthly rainfall for the months of July, October, and November in the Cherrapunji in Megalaya, India, has been increasing while monthly rainfall for the months of February to June, August, and September has been decreasing for the period 1872-2007. These results are statistically significant[5]. It has been found that both the Tmax and Tmin are increasing annually and the increasing rate is higher in daily Tmin as compared to daily Tmax in the subtropical region of Assam and its neighbouring states in NE India[6]. A study observed a significant declining rainfall trend for the monsoon season while the insignificant negative trend of rainfall for the winter and pre-monsoon seasons in the several regions of India for the1901 to 2015. Moreover, a significant negative trend was found for overall annual rainfall series[7]. It was observed that the majority of the people in the Barak Valley region of Assam were in view that major indicators of climate change are erratic rainfall, increase in temperature, high winds and prolonged drought[8]. Another study observed that annual rainfall was decreasing in the Brahmaputra Valley region of Assam during the period 1986-2015. Seasonal analysis revealed that pre-monsoon rainfall increased over 6 out of 10 selected stations whereas, post-monsoon and winter rainfall shown decreasing trends over all the stations[9]. A statistically significant increasing temperature trend was observed in some selected stations of Assam over the period spanning from 1901 to 2014[10]. Another study highlighted a mix of positive (increasing) and negative (decreasing) statistically significant trends in monthly and seasonal rainfall in Assam for the 1950- 2013[11].

3 Materials and Methods

3.1. Study Area

Karimganj district is located between the longitudes of 92°15' and 92°35' east and the latitudes of 24°15' and 25°55' north. Bangladesh and Cachar district border the district on the north; Mizoram and Tripura states border it on the south; Bangladesh and Tripura border it on the west; and Hailakandi district borders it on the east. The map of the district is presented at below.

3.2. Climate Data

Data on monthly and annual maximum temperatures (°C), minimum temperatures (°C) total rainfall (mm) and relative humidity (%) for the period 1981-2020 have been collected from https://power.larc.nasa.gov/data-access-viewer/ which is free to access (Retrieved on 15th December 2021). District level datasets have been downloaded from the portal using latitudes and longitudes for Karimganj district. The Indian Meteorological Department (IMD classified four meteorological seasons over India which are: Winter Season: January-February, Pre-Monsoon Season: March-May, Monsoon or also called South West Monsoon Season: June- September and Post Monsoon Season: October -December[12].

3.3. Trend Analysis

The Mann-Kendall (MK) approach[13,14] was used to construct a statistically significant trend in the series. It is a non-parametric rank-based approach that is resistant to the effects of extremes and may be used with skewed variables[15]. This method may be used with non-normally distributed data, data with outliers, and data with non-linear trends[16]. The MK test compares the alternative hypothesis of an increasing or declining trend against the null hypothesis of no trend. Equation (1) gives the MK

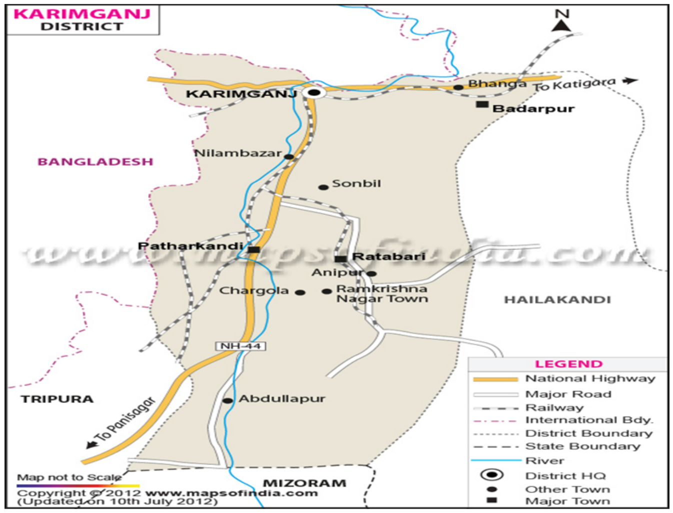

Fig 1. Source: Location map of karimganj district - Bing images (Accessed on 3rd February, 2022)

test statistic (S).

$$S = \sum_{k-1}^{n-1} \sum_{j=k+1}^{n} sign\ (\ x_j - x_{k)} \quad (1)$$

Where n is the time series length, x denotes the data point at times j and k (k>j), and equation denotes the sign function (2).

$$\text{sign}\left(x_{\mathrm{j}} - x_{\mathrm{k}}\right) = \begin{cases} +1, \text{ if } \left(x_{\mathrm{j}} - x_{\mathrm{k}}\right) > 0 \\ 0, \text{ if } \left(x_{\mathrm{j}} - x_{\mathrm{k})}\right. = 0 \\ -1, \text{ if } \left(x_{\mathrm{j}} - x_{\mathrm{k})}\right. < 0 \end{cases} \quad (2)$$

If n is less than 10, the value of [S] is directly compared to Mann Kendall's theoretical distribution of S. The statistic S is considered to be asymptotically normal for n=10 or greater, with a mean E(S)= 0 and variance as follows:

$$\text{Variance: Var}(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_t t(t-1)(2t+5)\right] \quad (3)$$

Where t is the size of a specific tie, and $\sum_t$ denotes the total number of ties. A tie occurs when two samples of data have the same value, and the summation is applied to all ties. Equation (4) calculates the standard normal deviation Z.

$$Z = \begin{cases} \dfrac{s-1}{\sqrt{\text{var}(s)}}, & \text{if } S > 0 \\ 0, & \text{if } S = 0 \\ \dfrac{s+1}{\sqrt{\text{var}(s)}}, & \text{if } S < 0 \end{cases} \quad (4)$$

Where Z (c) follows a normal distribution, positive Z (c) and negative Z (c) reflect an upward and downward trend throughout the time period, respectively. In a two-sided trend test, the null hypothesis Ho should be accepted if [Z]> Z (/2), at a level of significance. In this study, the null hypothesis is tested at a 95% confidence level. A simple non-parametric approach proposed by Sen was also used to assess the magnitude of a time series trend[17]. Equation (5) is used to calculate the trend.

$$\beta = median\left(\frac{x_{j-}\,x_k}{j-i}\right),\ j > i \quad (5)$$

where β is Sen's estimate of the slope. A time series with β>0 shows an upward trend. The data series, on the other hand, shows a declining tendency with time. All exercises have been done using 'RStudio' open-source software.

4 Results and Discussion

The trends of seasonal and annual temperature maximum (Tmax), temperature minimum (Tmin), rainfall and relative humidity for the Karimganj district of Assam spanning the period 1981-2020 have been obtained by Mann Kendall (MK) test. In addition, Sen's slope test has been used to detect the magnitudes. Our study is in line with other similar studies conducted in Northeast India as well as in different other parts of India[5–11]. The results will be very useful for policy makers for providing proper mitigation plans. It will also be helpful for farmers to take appropriate adaptation stagiaries to combat the adverse effects of climate change. The results of statistical tests and time series graphs are discussed below in details.

4.1 Annual Trends in climatic variables

The annual trends of temperature maximum (Tmax), temperature minimum (Tmin), rainfall and relative humidity are presented in Table 1. Among climatic variables, Annual Tmax is showing a statistically significant negative trend whereas rainfall and relative humidity are showing significant positive trends (Table 1) over the period. Tmin does not show any significant trends during the period. The magnitudes of the trends can be seen from Sen's slope test, -0.05, 0.02, 43.48 and 0.32 for Tmax, Tmin, rainfall and relative humidity, respectively. The time series graph, along with linear trend line is represented by Figure 2.

Table 1. Results of Statistical Tests for Annual Climatic Variables

Climate Variables	Mann Kendall Test			Sen's slope
	S	Z	P value	
Tmax	-230	-2.6681*	0.0076	-0.05
Tmin	131	1.5151	0.1297	0.02
Rainfall	462	5.3711*	<0.0001	43.48
Relative Humidity	455	5.2906*	<0.0001	0.32

*Indicates statistically significant at 5% level of significance

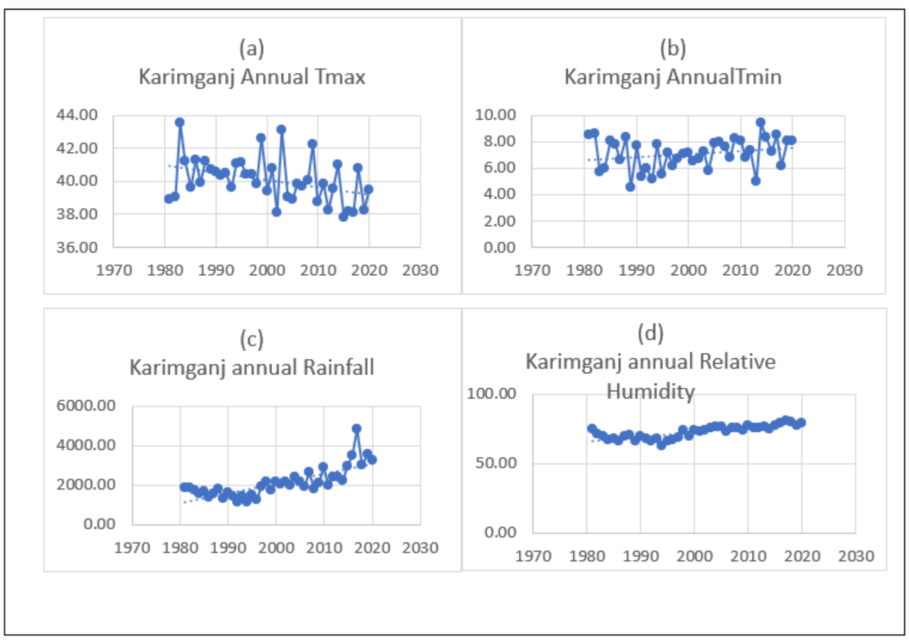

Fig 2. Observed trend lines and time series graphs for annual climatic variables. **Source:** Author's own calculation based on Secondary data collected from NASA POWER Project [https://power.larc.nasa.gov/data-access-viewer/

4.2 Trends in Winter Climatic Variables

During winter season, temperature maximum (Tmax) is showing a significant negative trend whereas temperature minimum and relative humidity are showing significant positive trends (Table 2). Rainfall is showing a positive trend but the result is statistically insignificant. The magnitudes of trends are -0.04, 0.02, 0.11 and 0.57 for Tmax, Tmin, rainfall and relative humidity, respectively. The observed trend lines and time series graphs are displayed in the Figure 3.

Table 2. Results of Statistical Tests for Winter Climatic Variables

Climate Variables	Mann Kendall Test			Sen's slope
	S	Z	P value	
Tmax	-253	-2.9363*	0.0033	-0.04
Tmin	159	1.841**	0.0656	0.02
Rainfall	69	0.7923	0.428	0.11
Relative Humidity	392	4.5568*	<0.0001	0.57

*Indicates statistically significant at 5% level of significance

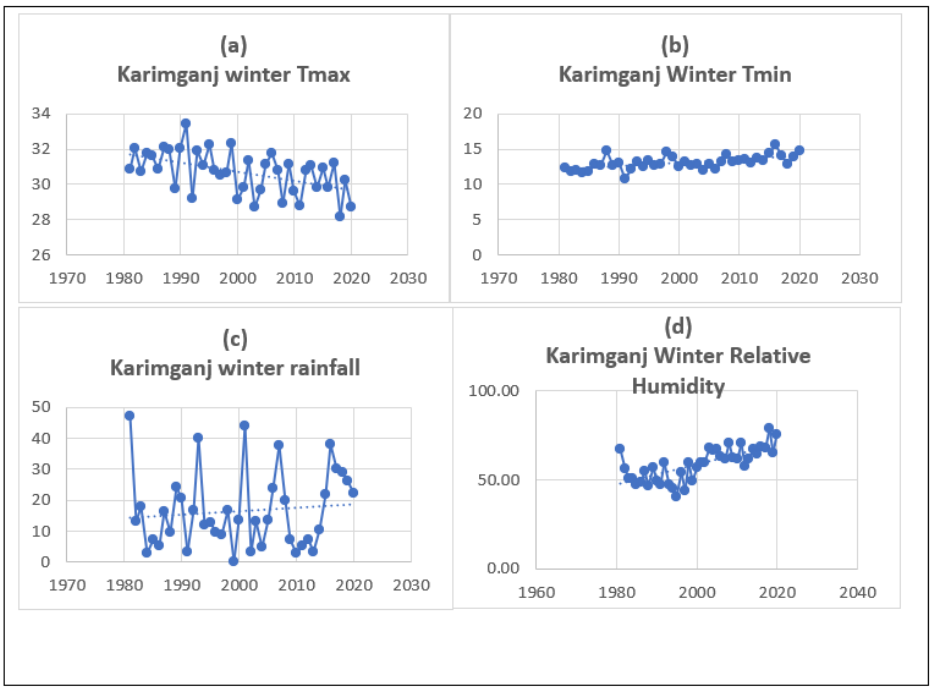

Fig 3. Observed trend lines and time series graphs for winter season climatic variables. **Source:** Authors' own calculation based on Secondary data collected from NASA POWER Project [https://power.larc.nasa.gov/data-access-viewer/

4.3 Trends in Pre-monsoon Climatic Variables

The temperature maximum (Tmax) is showing a significant negative trend in pre-monsoon season also. Temperature minimum (Tmin), rainfall and relative humidity are showing statistically significant positive trends over the period (Table 3). The magnitudes of trends are -0.06, 0.03, 4.29 and 0.42 for Tmax, Tmin, rainfall and relative humidity, respectively. The observed trend lines and time series graphs are exhibited in the Figure 4.

Table 3. Results of Statistical Tests for Pre-monsoon Climatic Variables

Climate Variables	Mann Kendall Test			Sen's slope
	S	Z	P value	
Tmax	-263	-3.0528*	0.0022	-0.06
Tmin	253	2.9367*	0.0033	0.03
Rainfall	378	4.3924*	<0.0001	4.29
Relative Humidity	358	4.1594*	<0.0001	0.42

*Indicates statistically significant at 5% level of significance

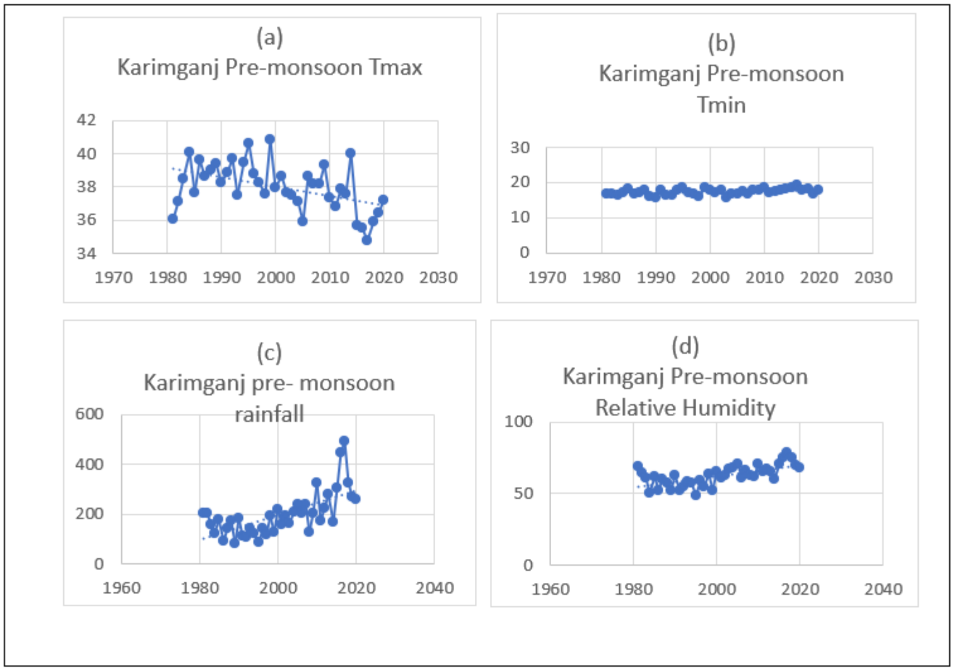

Fig 4. Observed trend lines and time series graphs for pre-monsoon climatic variables. **Source:** Author's own calculation based on Secondary data collected from NASA POWER Project [https://power.larc.nasa.gov/data-access-viewer/

4.4 Trends in Monsoon Climatic Variable

In case of monsoon season, again temperature maximum (Tmax) is showing a statistically significant negative trend whereas temperature min (Tmin), rainfall and relative humidity are showing significant positive trends (Table 4). The magnitudes of trends are -0.03, 0.02, 6.50 and 0.11 for Tmax, Tmin, rainfall and relative humidity, respectively. The observed trend lines and time series graphs are depicted in the Figure 5.

Table 4. Results of Statistical Tests for Monsoon Climatic Variables

Climate Variables	Mann Kendall Test			Sen's slope
	S	Z	P value	
Tmax	-245	-2.843*	0.0044	-0.03
Tmin	418	4.859*	<0.0001	0.02
Rainfall	472	5.4876*	<0.0001	6.50
Relative Humidity	384	4.4623*	<0.0001	0.11

*Indicates statistically significant at 5% level of significance

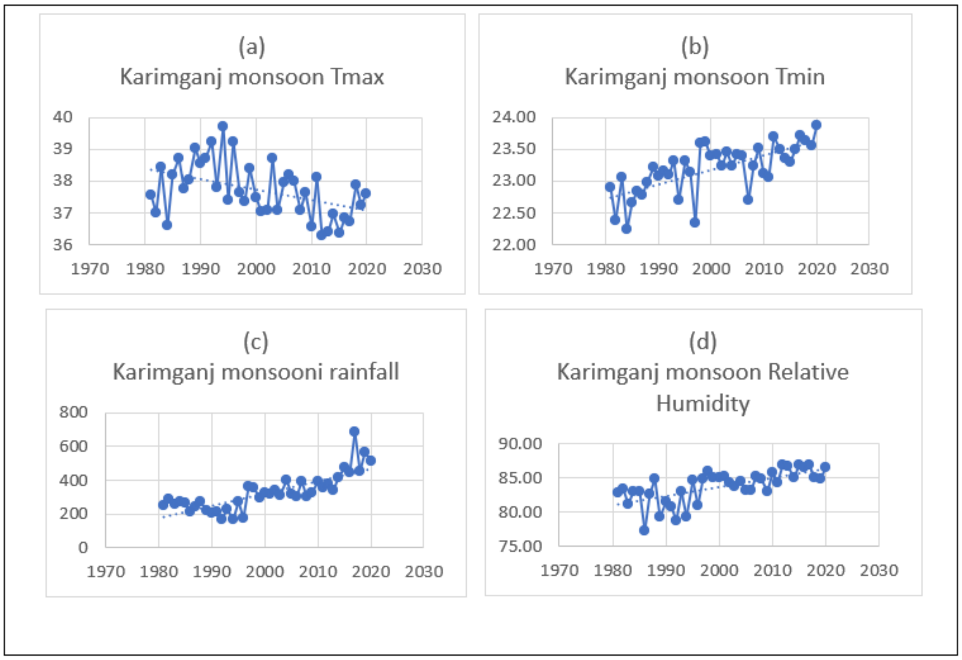

Fig 5. Observed trend lines and time series graphs for monsoon climatic variables. **Source:** Author's own calculation based on Secondary data collected from NASA POWER Project [https://power.larc.nasa.gov/data-access-viewer/]

4.5 Trends in Post Monsoon Climatic variables

During post Monsoon season, Temperature maximum (Tmax) is showing a negative trend but statistically insignificant. However, Temperature minimum (Tmin), rainfall and relative humidity are showing significant positive trends over the period (Table 5). The magnitudes of trends are -0.01, 0.05, 1.39 and 0.22 for Tmax, Tmin, rainfall and relative humidity, respectively. The time series graph, along with linear trend line is represented by Figure 6.

Table 5. Results of Statistical Tests for Post Monsoon Climatic Variables

Climate Variables	Mann Kendall Test			Sen's slope
	S	Z	P value	
Tmax	-56.	-0.6408	0.5216	-0.01
Tmin	360	4.1833*	<0.0001	0.05
Rainfall	244	2.8312*	0.0046	1.39
Relative Humidity	470	5.4643*	<0.0001	0.22

*Indicates statistically significant at 5% level of significance

5 Conclusion

This piece of study is an attempt to establish the occurrence of climate change in the Karimganj district of Assam, India. In this study, the variability and long-term trends of seasonal and annual temperature maximum, temperature minimum, average rainfall and relative humidity for the Karimganj district of Assam are examined. The study is unique and innovative for Karimganj district of Assam to best of our knowledge. It has been observed that annual and seasonal temperature maximum (Tmax) are showing a statistically significant negative trend over the period 1981-2020 during all seasons except for post monsoon season. The magnitude of trend for annual Tmax is -0.05 as indicated by Sen's slope. The annual temperature minimum (Tmin) series does not show any significant trends whereas seasonal mean temperature minimum is showing a positive trend at different levels of significance during all four seasons. Except winter season, annual rainfall series and all other seasonal average rainfall series are showing significant positive trends. The magnitude of annual rainfall trend is 43.48. The Annual and seasonal

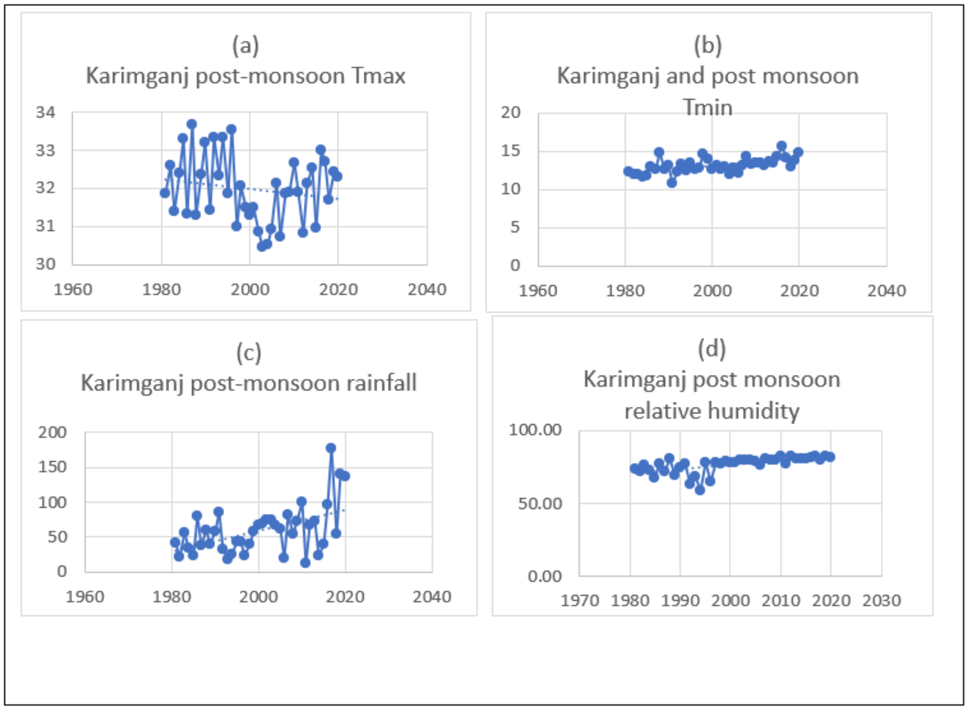

Fig 6. Observed trend lines and time series graphs for post monsoon climatic variables. **Source:** Author's own calculation based on Secondary data collected from NASA POWER Project [https://power.larc.nasa.gov/data-access-viewer/]

average relative humidity are showing statistically significant positive trends over the period. The magnitude of annual average relative humidity is 0.32. This study confirms that climate change is occurring in the Karimganj district of Assam. Suitable adaptation strategies and government's policy intervention regarding mitigation are crucial to combat the present and future potential impacts of climate change.

References

1) Deka RL. Climate Change in the Brahmaputra valley and impact on Rice yield and Tea Production. Doctoral thesis, Centre for Environment, Indian Institute of Technology Guwahati. 2013. Available from: http://gyan.iitg.ernet.in/bitstream/handle/123456789/416/TH-1188_0865206.pdf?sequence=1&isAllowed=y.
2) DST. Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework. Report of the Department of Science and technology, Government of India. 2020. Available from: https://dst.gov.in/sites/default/files/Full%20Report%20%281%29.pdf(Accessedon13thNovember2021).
3) Jain SK, Kumar V. Trend analysis of rainfall and temperature data for India. *Current Science*. 2012;10:37–49. Available from: https://www.researchgate.net/publication/275340859.
4) Zhang P, Zhang J, Chen M. Economic impacts of climate change on agriculture: The importance of additional climatic variables other than temperature and precipitation. *Journal of Environmental Economics and Management*. 2017;83(1):8–31. Available from: https://dx.doi.org/10.1016/j.jeem.2016.12.001. doi:10.1016/j.jeem.2016.12.001.
5) Deka S. Statistical analysis of long-term rainfall trends in Cherrapunji, Meghalaya, India. *Journal of Applied and Natural Science*. 2021;13(1):170–177. Available from: https://doi.org/10.31018/jans.v13i1.2442.
6) Deb S, Sil BS. Trend analysis of climatic variables for the subtropical region of Assam and its neighboring states in NE India. *Indian Journal of Geo Marine Sciences*. 2020;p. 1359–1371. Available from: http://nopr.niscair.res.in/handle/123456789/55313.
7) Praveen B, Talukdar S, Mahato S, Mondal J, Sharma P, Islam AR, et al. Analyzing trend and forecasting of rainfall changes in India using non-parametrical and machine learning approaches. *Scientific Reports*. 2020;10(1):1–21. Available from: https://dx.doi.org/10.1038/s41598-020-67228-7.
8) Majumder SH, Deka N, Mondal B, Bisen J, Barman U. Farmers' Perception to Climate Change in Barak Valley Zone of Assam: An Empirical Study. *Indian Journal of Extension Education*. 2019;55(4):97–101. Available from: https://www.indianjournals.com/ijor.aspx?target=ijor:ijee3&volume=55&issue=4&article=018.
9) Gharphalia BJ, Deka RL, Islam AN, Dutta P, Medhi K. Variability and Trends of Rainfall Events in the Brahmaputra Valley of Assam. *International Journal of Current Microbiology and Applied Sciences*. 2018;7(11):1902–1912. Available from: https://dx.doi.org/10.20546/ijcmas.2018.711.215.
10) Dutta UP, Gogoi PP, Sengupta PP, Phukon P. Time Series Analysis of Temperature and Rainfall in the Brahmaputra Basin. Assam. Urban India. 2018. Available from: https://www.researchgate.net/publication/333968478_Time_Series_Analysis_of_Temperature_and_Rainfall_over_Brahmaputra_Basin_Assam?enrichId=rgreq-f1bd130c344817e0d389eba193324c9f-XXX&enrichSource=

Y292ZXJQYWdlOzMzMzk2ODQ3ODtBUzo3NzMwMDUxMDE3ODA5OTVAMTU2MTMxMDE4NjgxMg%3D%3D&el=1_x_2&_esc=publicationCoverPdf.

11) Singh A, Adhikary NC. Rainfall Trends in six districts of Assam during the period 1950- 2013. *Research Journal of Chemical and Environmental Sciences*. 2018;6(4):54–63. Available from: http://www.aelsindia.com/august_2018/12.pdf.
12) Attri SD, Tyagi A. Climate profile of India. Environment Monitoring and Research Center. 2010. Available from: http://uchai.net/pdf/knowledge_resources/Publications/Reports/Climate%20Profile%20India_IMD.pdf.
13) Mann HB. Nonparametric Tests Against Trend. *Econometrica: Journal of the econometric society*. 1945;13(3):245–245. Available from: https://doi.org/10.2307/1907187.
14) Kendall MG. Rank Correlation Methods. New York, NY. Oxford University Press. 1975. Available from: https://www.scirp.org/(S(i43dyn45teexjx455qlt3d2q))/reference/ReferencesPapers.aspx?ReferenceID=1749771.
15) Hamed KH. Trend detection in hydrologic data: The Mann–Kendall trend test under the scaling hypothesis. *Journal of Hydrology*. 2008;349(3-4):350–363. Available from: https://doi.org/10.1016/j.jhydrol.2007.11.009.
16) Helsel DR, Hirsch RM. Statistical methods in water resources. Elsevier. 1992. Available from: https://books.google.com/books?hl=en&lr=&id=jao4o5X1pvgC&oi=fnd&pg=PP2&dq=17.%09Helsel+DR,+Hirsch+RM.+1992.+Statistical+Methods+in+Water+Resources.+Vol.+49.+Elsevier.&ots=QWTB8NjbNZ&sig=yoY3M_bW4wuCjq5qz6-zeVkqM8I(Accessedon18th.
17) Sen PK. Estimates of the Regression Coefficient Based on Kendall's Tau. *Journal of the American Statistical Association*. 1968;63(324):1379–1389. Available from: http://links.jstor.org/sici?sici=01621459%28196812%2963%3A324%3C1379%3AEOTRCB%3E2.0.CO%3B2-A.