

Original Research Article

Analysis of spatially distributed monthly rainfall and temperature in Bangladesh

Abstract: In this study, based on the analysis of historical data on temperature and rainfall recorded at 34 meteorological stations, we reveal Climate change and variability in Bangladesh from 1989-2019. Analysis of rainfall data showed that for most stations, the total rainfall showed an increasing trend for the monsoon and post-monsoon seasons. The average increase in monthly average maximum and minimum temperatures during the 31 years from 1989 to 2019 is quite significant. These changes will threaten Bangladesh's significant achievements over the last 31 years in increasing incomes and reducing poverty. Analysis of rainfall data showed a rising rainfall trend for most stations during the monsoon and post-monsoon seasons. Analysis of rainfall data showed that rain increased during and after the monsoon but decreased during the winter. Assessment of changes in maximum temperature, minimum temperature, and rainfall patterns. Bangladesh's annual maximum temperature was increasing on average by 34 stations. The greatest change in month-average maximum temperature was found in the Southeastern region of Bangladesh for maximum months.

Keywords: *Climate variability, Monthly Temperature, Monthly Rainfall, spatial distribution, SVM.*

1. INTRODUCTION:

Climate is one of the key components in the earth system. It is the statistical description in terms of the mean and variability of relevant

Comment [u1]: The title needs refinement probably to **Spatio-temporal Variability of Temperature and Rainfall in the last three decades (1991-2021) in Bangladesh**. Check the objective of the report and then edit the title or the heading. **Would you check whether it is spatio-temporal distribution or pattern and projection?**

Comment [u2]: Why not give a statement on the background of the problem and the need to deal with the theme of the study at hand?

Comment [u3]: ..the authors revealed

Comment [u4]: To fit to the IPCC report, it is good to readjust the duration of the study from 1991 to 2021.

Comment [u5]: What methods of data collection did you use and what about the types of the data analysis?

Comment [u6]: Would you put the increment in a brief quantitative manner than the qualitative alone?

Comment [u7]: At what level of significance? It is good to specify the level.

Comment [u8]: It seems a statement of vulnerability or exposure but did you make any analysis of that or is it speculation alone?

Comment [u9]: It needs quantification.

Comment [u10]: Why incomplete sentence?

Comment [u11]: Can these stations represent the nation at large?

Comment [u12]: It is good to avoid very vague statements.

Comment [u13]: What about including Bangladesh in the keywords but in an alphabetic orders.

quantities over a period of time ranging from months or millions of year (IPCC, 2007)[[6]. The fourth Assessment report of IPCC(2007)[7] has observed that the 100-year linear trend (1906-2005) of global average surface temperature is 0.74 (0.56 to 0.92) and is longer that the corresponding trend of 0.6 (0.4 to 0.8) (1901-2000). The trends of yearly average maximum and minimum temperatures have been found to be increasing at the rates of 0.025°C and 0.018 °C per year by Das & Zhang (2021)[2]. Warrick et al (1994)[14], Karmakar & Shrestha (2000)[9] and Debsarma (2003)[4] provided assessment of changes in temperature and rainfall over Bangladesh, while Chowdhury & Debsarma (1992)[1] and Mia (2003)[12] reported changes in temperature based on analysis of historical data of some selected weather stations in Bangladesh, Karmakar & Nessa (1997)[8] and Karmakar (2003)[10] provided assessment of the effects of climate change on natural disasters. The rainfall and temperatures (Singh et al. 2013) are the most important fundamental physical parameter among the climate as these parameters determine the environmental condition of the particular region which affects the agricultural productivity (Modarses and da Silva, 2007)[11].

In Bangladesh, different climate changes like recurring floods, river, bank erosion, and drought in dry season, salinity increase as a result of back water effect; downing ground water level, have been contributing to augment the vulnerability of many regions. Bangladesh is one of the top most nations vulnerable to climate change (Harmeling, 2008)[5]. Nevertheless, many regions of this country remain outside the ambit of climate change related actions (Titumir & Basak, 2012)[13]. Das, Islam & Ghosh (2022)[3] showed that, in Bangladesh January is the coldest month and April is the hottest month, where the average temperature is 18 °C, and 28 °C, respectively. Modeling studies by Haque et al (1992)

Comment [u14]: Would you check for the 6th assessment as it is recently published in 2022?

Comment [u15]: Do we need both the source and its note of sequence in the text? I guess one of them should be removed. And why two sequences for the same source/reference? What about for those from 1 to 5 in the sequence as this starts from number 6?

Comment [u16]: ...that or than?

Comment [u17]: Same to the above comment regarding reference citation in the text.

Comment [u18]: It is good to avoid such long sentences.

calculated the increasing temperature for the projected years of 2030 and 2075 would be 1.3 °C and 2.6 °C respectively.

2. DATA SETS AND METHODOLOGY

The study was conveyed on 34 meteorological stations in Bangladesh for the period of 1989 to 2019 and their geographical locations are shown in figure 1. Among them Bogra, Dinajpur, Rangpur and sayedpur were selected for Nothern region, Chuadanga, Faridpur, Ishurdi and Rajshahi were slected for Northwestern region; Jessore, Khulna, Mongla, Patuakhali, Satkhira and Khepupara for North Southern region; Tangil, Dhaka and Mymensingh for central region; Barisal, Bhola, Chandpur, Comilla, Feni, Hatiya, M.Court, Madaripur for Sothern region; Chittagong, Cox'sbazar, Kutubdia, Rangamati, Shandwip, Sitakunda and Teknaf for Southeastern region and sylhet and Srimongal for Eastern region in Bangladesh.

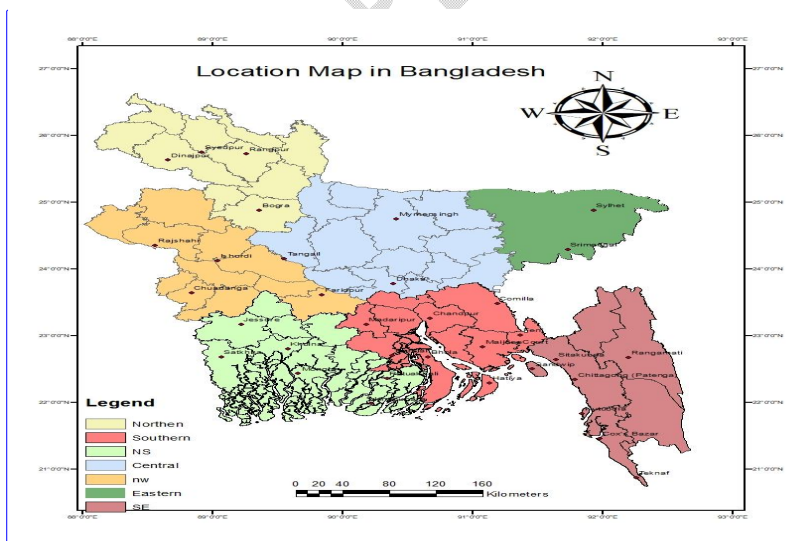


Fig-1 Location Map of the study area

Comment [u19]: Avoid unnecessary wastage of spaces.

Comment [u20]: The study area should be clearly stated in one separate section while the method of data collection and analysis also need serious and detailed presentations and discussion supported with proper references.

Comment [u21]: Adjust to 1991 to 2021 as per the comment conveyed above.

Comment [u22]: There is a need to put their other details of description including year of establishment, status of the stations,

Comment [u23]: This may make the list boring. Why not you put the list of stations make in a table with different descriptive parameters like location, altitude, status/rank of the stations, year of establishment, and other characteristics?

Comment [u24]: Check the clarity and visibility of the location map of the study area.

We collected temperature and rainfall data of all 34 weather stations from Meteorological Department of Bangladesh. These data included daily, monthly average and annual mean for the period January 1989 to December 2019.

Comment [u25]: For scientific report, it is not advisable to use we unless it is an action research or so.

Comment [u26]: Check the spelling.

2.1 RMSE, MAE, and MAPE: Using RMSE, MAE, and MAPE metrics, the LSTM model's performance in predicting temperature was assessed. The following equation can be used to determine the RMSE, which is a measure of the,

Comment [u27]: Where is 2.2 and above or is it by mistake that you made only 2.1. As to me, you should make 2.1 Description of the study area, and 2.2. method of data collection and analysis where you are expected to give complete and proper discussion and explanations on the titles accordingly.

Comment [u28]: It is necessary to cite the source of the equation.

$$RMSE = \sqrt{\frac{1}{n} \sum_{t=1}^n (y_t - \hat{y}_t)^2}$$

The MAE (mean absolute error) is a measurement of the discrepancies between predictions and actual observations.

Comment [u29]: Same regarding the original source and its description.

$$MAE = \frac{1}{n} \sum_{t=1}^n |y_t - \hat{y}_t|$$

The following equation can be used to calculate MAPE, which expresses the error as a percentage between expected and observed data.

Comment [u30]: Same to the above comment.

$$MAPE = \left(\frac{1}{n} \sum_{t=1}^n \left| \frac{y_t - \hat{y}_t}{y_t} \right| \right) \times 100\%$$

The discrepancy between actual observations and the model's projected results is measured by the assessment metrics mentioned above. As a result, the model's accuracy rises as the RMSE, MAE, and MAPE values fall. These numbers are computed using the test set predictions.

3. RESULT AND DISCUSSION

Trend is defined as the general movement of a series over an extended period of time it is the long term change in the dependent variable over a long period of time (Webber and Hawkins, 1980)[15]. Trend is determined by the relationship between the two variables of temperatures rainfall and their temporal resolution. The statistical method such as regression analysis and coefficient of determination R^2 are used for the significance of trend of temperature and rainfall.

Comment [u31]: Why not you state this in the method of data analysis including their detailed descriptions and explanations?

3.1 Rainfall pattern: The whole year divided into four seasons to assessed changes in rainfall pattern by analyzing changes in total rainfall for the period of 1989 to 2019. The hot season start from March to May which is called pre-monsoon, June to September is Monsoon, October and November constitute the post-monsoon season. The cold season is from December to February which is winter. In this study, we observed the significant change in trends of rainfall. In winter season of Bangladesh among the 34 stations, 2 stations showed increasing trend while 32 showed decreasing trends in total rainfall. On the other hand, for monsoon season showed rising trend in 31 stations; 30 stations showed increasing trend of total rainfall for post monsoon and 20 stations for pre-monsoon among 34 weather stations. Moreover, the observed trends were not statistically significant in most cases. Nevertheless, majority of stations showed increasing trend of rainfall during monsoon and post-monsoon season while significant number of stations showed decreasing trend of total rainfall during winter. From analysis of total rainfall we observed that the results are consistent with the general climate change predictions that day periods would become drier and wet periods would become wetter. In Bangladesh during the period of 1989–2019, the yearly average rainfall increased in the southern and southeastern region. while the yearly average rainfall decreased at the remaining regions for the northern, northwestern, north southern, central and eastern regions, respectively.

Comment [u32]: Is there any source to support this?

Comment [u33]: Check similar comments stated above.

Comment [u34]: Do not leave space unnecessarily.

Table-1: Amount of Rainfall (mm per year) in four Seasons during 1989-2019

Region	Winter	Pre-monsoon	Monsoon	Post-monsoon
Northern	0.293	3.463	10.857	2.313
NorthWestern	0.407	2.867	8.651	2.401
NorthSouthern	0.509	3.455	11.900	3.584
Central	0.408	4.802	10.787	3.150
Southern	0.421	4.736	16.122	4.458
SouthEastern	0.449	5.484	18.882	4.664
Eastern	0.602	9.777	16.263	3.461

we observed that the highest change of the rainfall was recorded for monsoon season in Bangladesh for maximum months and the lowest changes for winter season during the period of 1989-2019. Analysis of changes in total rainfall was made separately for each weather station. The southwest monsoon is the principle source of rainfall in Bangladesh. About 80% of the total rainfall is received during the monsoon. The variation in the annual rainfall and temperature from year to year is not very large.

Comment [u35]: Same to the above similar comments.

3.2 Rainfall Prediction:

We practiced Linear Regression, used Test & Score to assess how well they performed. By building a learner or predictor from its input data, the linear regression widget creates a linear function.

Comment [u36]: Why not support the explanation using a map of the regins and that of

Comment [u37]: Check the previous comments on it.

Comment [u38]: Did you mention/introduce about this in the methodology part?

The history of decision trees and how they're trained, many forecasters utilizes regression trees to accurately anticipate load demand. The training data is separated into sub-units of data in a decision tree.

Comment [u39]: Could you support this with proper and supportive reference?

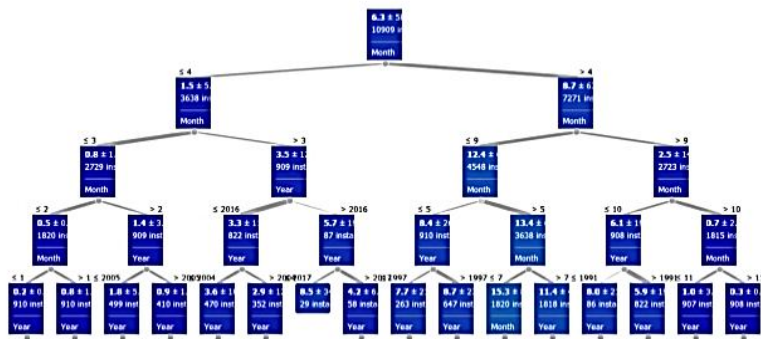


Fig 2: Rainfall forecast result using DT compared with observed value.

3.3 Temperature Patterns

The study's utilization of temperature data from 34 meteorological stations is described.

Table 2: Lists the 34 meteorological stations temperature data

No	Station Name	Climate Region	latitude (N)	longitude (E)	Minimum (Temperature)	Maximum (Temperature)	Period of Record used
1	Bogura	Northern	24°51'	89°22'	21.984	31.591	1989-2019
2	Dinajpur	Northern	25°33'	88°43'	20.689	30.966	1989-2019
3	Rangpur	Northern	25°42'	89°22'	20.878	30.542	1989-2019
4	Sayedpur	Northern	25°48'	89°0'	20.737	30.672	1989-2019
5	Chuadanga	Northwestern	23°64'	88°85'	21.406	32.448	1989-2019
6	Faridpur	Northwestern	23°15'	89°55'	22.141	31.936	1989-2019

Comment [u40]: It is good to put this list in the appendices but only the details of the discussions and analysis in the body of the report. It is also essential to minimize the page of the table by condensing it.

Comment [u41]: It is good to put in a bold for they are the headings of the table.

7	Ishurdi	Northwest ern	24°12'	89°06'	21.478	31.920	1989-2019
8	Rajshahi	Northwest ern	24°22'	88°39'	21.339	32.184	1989-2019
9	Jessore,	North Southern	23°10'	89°10'	21.712	32.920	1989-2019
10	Khulna,	North Southern	22°25'	89°35'	22.763	31.943	1989-2019
11	Mongla,	North Southern	22°49'	89°60'	23.205	31.768	1989-2019
12	Patuakhali,	North Southern	22°20'	90°25'	22.897	31.661	1989-2019
13	Satkhira	North Southern	22°31'	89°11'	22.485	31.996	1989-2019
14	Khepupara	North Southern	22°00'	90°22'	22.815	31.672	1989-2019
15	Tangil,	Central	24°40'	90°00'	21.385	31.661	1989-2019
16	Mymensingh	Central	24°45'	90°24'	21.645	30.489	1989-2019
17	Dhaka	Central	25°46'	89°42'	23.111	31.892	1989-2019
18	Barisal	Southern	22°45'	90°20'	22.521	31.523	1989-2019
19	Bhola,	Southern	22°45'	90°35'	22.421	31.400	1989-2019

20	Chandpur,	Southern	23°08'	90°45'	22.726	31.627	1989-2019
21	Comilla,	Southern	23°28'	91°10'	22.502	32.154	1989-2019
22	Feni,	Southern	23°01'	91°40'	22.106	31.547	1989-2019
23	Hatiya	Southern	22°29'	91°14'	22.716	30.930	1989-2019
24	M. Court	Southern	22°88'	91°09'	23.289	32.295	1989-2019
25	Madaripur	Southern	23°19'	90°15'	21.666	30.266	1989-2019
26	Chittagong	Southeastern	22°19'	91°48'	23.088	31.373	1989-2019
27	Cox'sbazar,	Southeastern	21°26'	91°59'	23.305	31.705	1989-2019
28	Kutubdia,	Southeastern	21°81'	91°85'	23.164	30.850	1989-2019
29	Rangamati	Southeastern	22°65'	92°18'	21.969	31.927	1989-2019
30	Shandwip,	Southeastern	22°59'	91°50'	23.054	31.636	1989-2019
31	Sitakunda	Southeastern	22°62'	91°68'	21.936	32.529	1989-2019
32	Teknaf	Southeastern	20°86'	92°30'	22.860	31.339	1989-2019
33	Sylhet	Eastern	24°54'	91°52'	21.613	31.450	1989-2019
34	Srimongal	Eastern	24°31'	91°73'	20.486	31.63	1989-2019

Comment [u42]: This column requires serious adjustments.

Comment [u43]: The table is poorly prepared and it requires serious refinement.

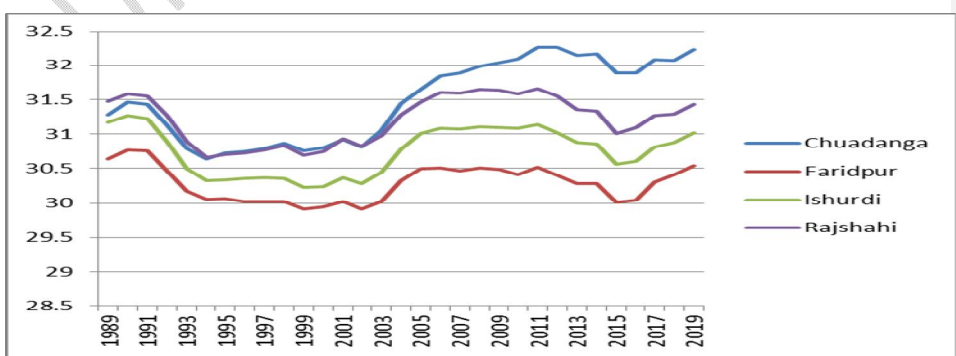
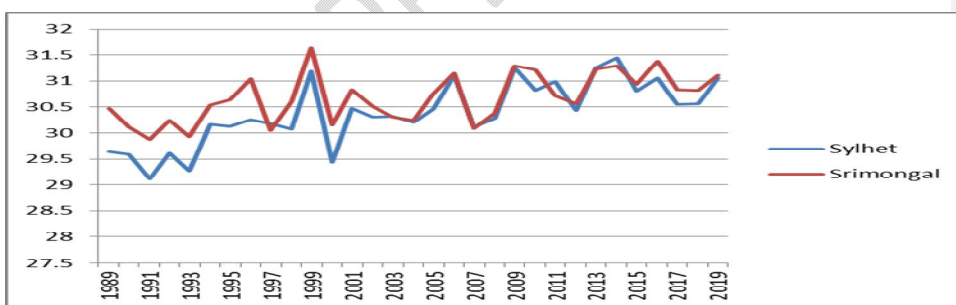
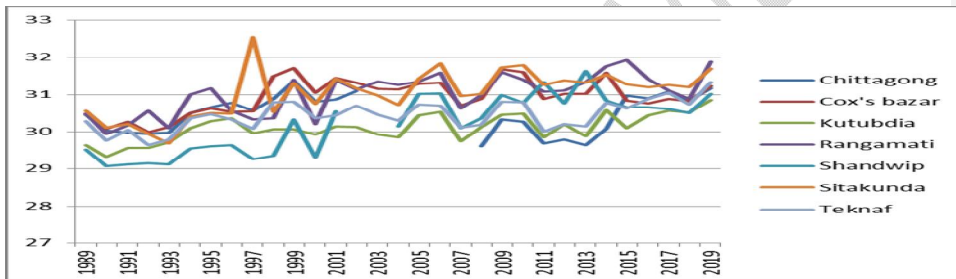
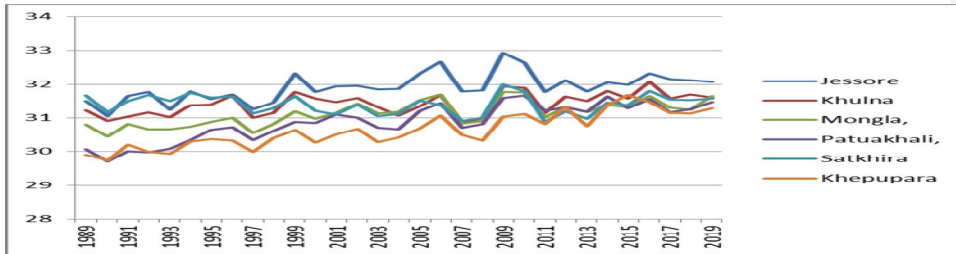
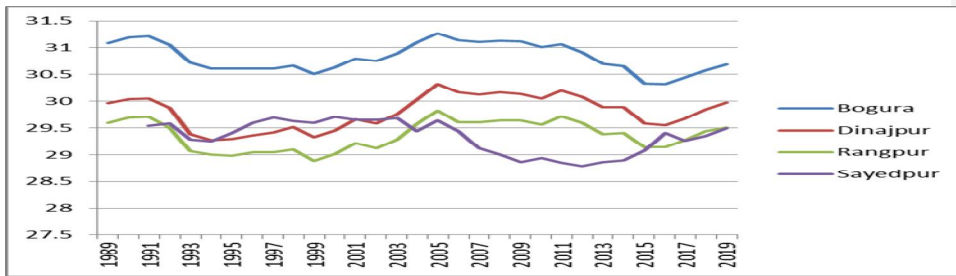
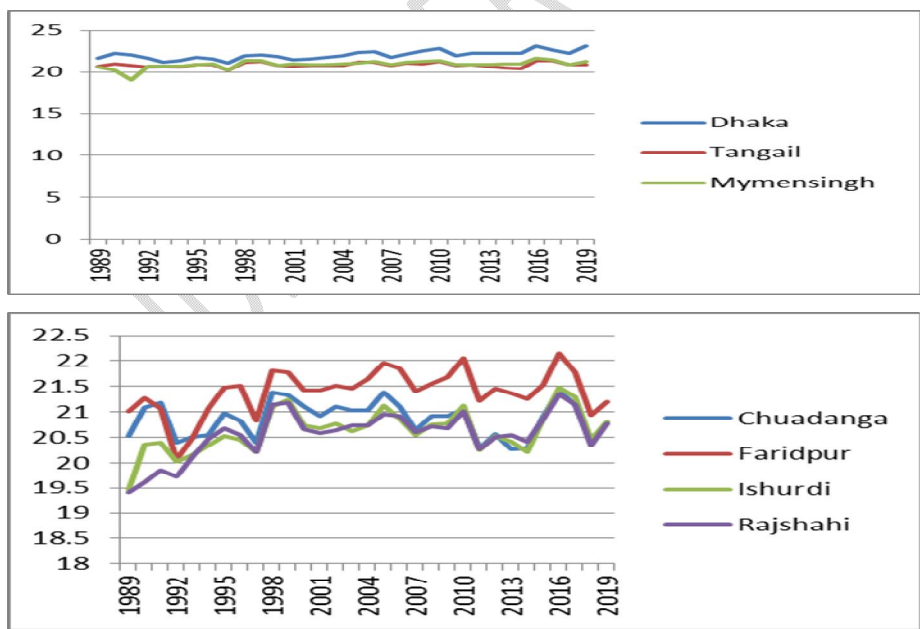
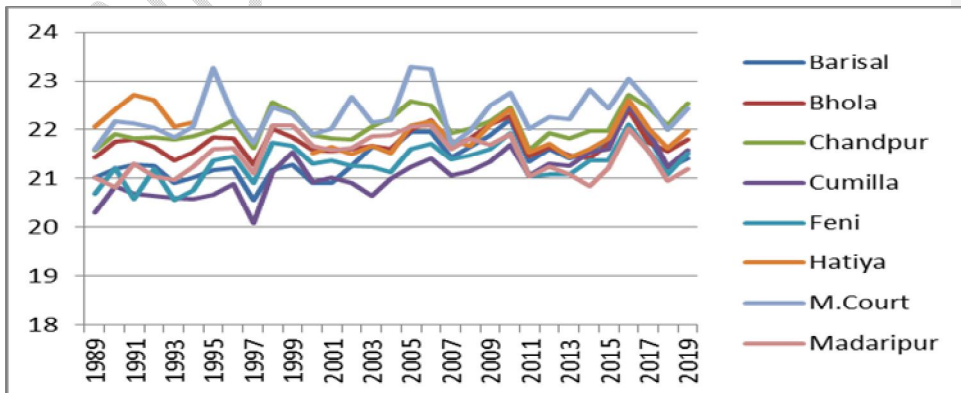
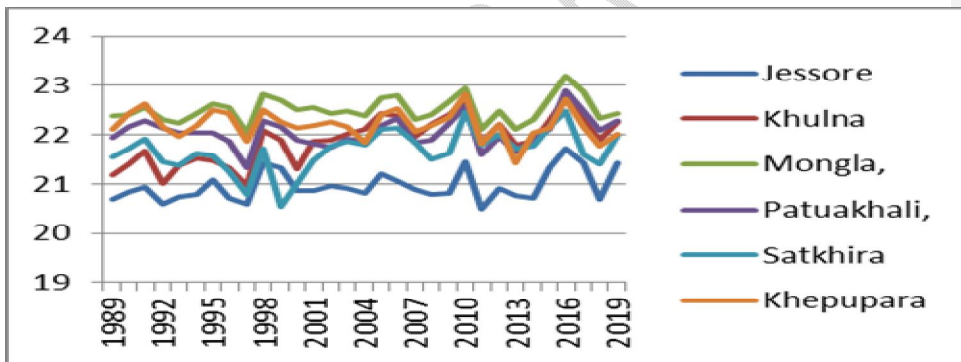
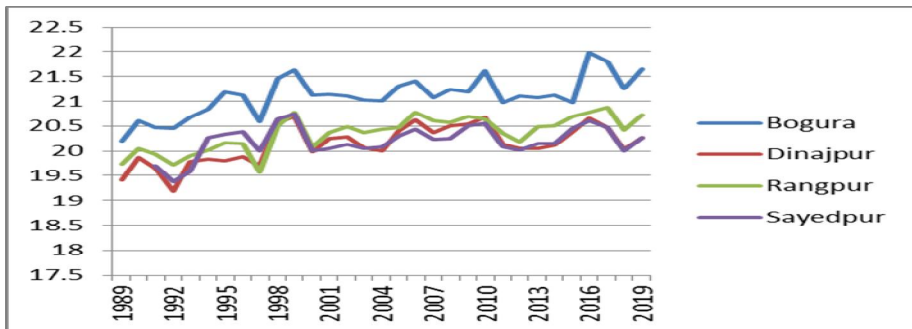
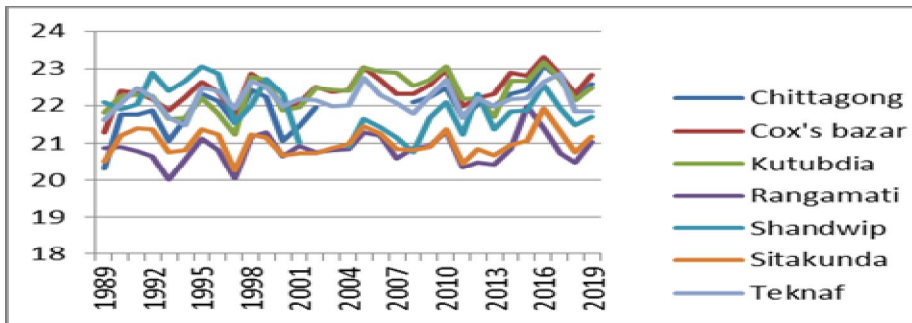


Fig-3: Yearly average maximum high and low temperature changed at different region in Bangladesh.

3.5 Average minimum high and low temperature:

Yearly average minimum temperature also have been increased in all regions of Bangladesh during the past 31-years period. The yearly average minimum high temperature was 21.073°C, 21.591°C, 22.468°C, 22.047°C, 22.494°C, 22.768°C, 21.049°C yearly. And average minimum low temperature were 19.581°C, 19.804°C, 21.132°C, 20.103°C, 21.078°C, 20.861°C, 18.821°C, for Northern, North-Western, North-southern, Central, Southern, Southeastern and Eastern region respectively here minimum low temperature was 18.821°C, minimum high temperature was 22.768°C.





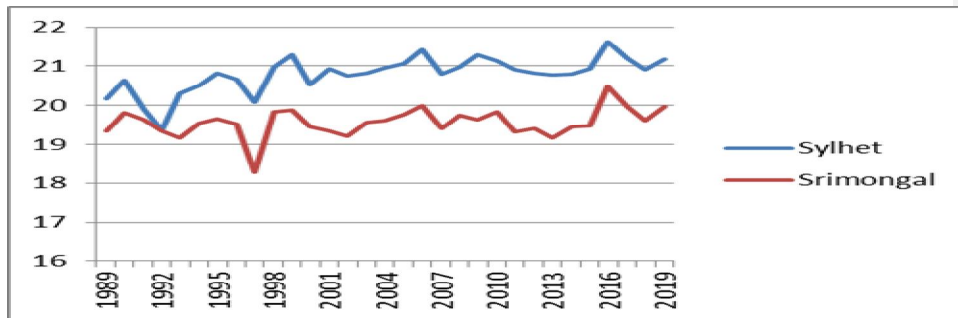


Fig-4: Yearly average minimum high and low temperature changed at different region in Bangla

3.6 Monthly Average Maximum Temperature

Table 3: Monthly Average Maximum Temperature from 1989-2019

Month	Jan	Feb	Mar	Apr	May	June	July	August	Sep	Oct	Nov	Dec
North ern	22. 79 8	26. 4 44	30. 35 9	31. 74 3	32. 22 6	32. 146	31. 785	32. 13 1	31. 722	30. 92 4	28. 89 3	25. 097
North weste rn	24. 08 9	28. 1 53	32. 96 1	35. 45 4	34. 94 5	33. 826	32. 603	32. 82 5	32. 497	31. 69 4	29. 38 4	25. 522
North South	25. 43	29. 0	32. 81	34. 45	34. 63	33. 125	31. 949	31. 89	32. 343	31. 90	29. 97	26. 687

ern	8	46	2	9	8			6		9	2	
Centr	24.	27	31.	33.	30.	32.	31.	32.	32.	31.	29.	25.
al	26	.7	56	21	01	483	923	22	172	73	61	944
	2	14	4	5	1			9		6	4	
South	25.	28	31.	32.	33.	31.	31.	31.	31.	31.	30.	26.
ern	19	.3	54	96	14	993	400	70	867	68	04	539
	3	40	9	5	0			3		1	8	
South	26.	28	31.	32.	32.	31.	30.	31.	31.	31.	30.	27.
Easter	76	.8	53	42	69	572	794	23	718	66	24	336
n	5	91	4	6	9			3		6	3	
Easter	25.	28	31.	32.	31.	31.	32.	32.	32.	31.	29.	28.
n	36	.2	39	12	91	946	291	65	379	71	70	254
	9	49	5	0	2			6		6	2	

Comment [u44]: why this table in the appendix while the data in a flow chart?

Changes in Monthly Average Maximum Temperature per year during 1989-2019

We observed that the highest change of monthly average maximum temperature was found for eastern region in Bangladesh, whereas the lowest change was found for Southern region in Bangladesh during the period of 1989-2019. In the similar way of monthly average maximum temperature we got changes of monthly average minimum temperature.

Comment [u45]: Check and revise accordingly.

3.7 Monthly Average Minimum Temperature

Table 4: Monthly Average Minimum Temperature from 1989-2019

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern	10.6	13.63	17.68	21.188	23.31	25.17	25.85	25.99	24.994	22.295	17.136	12.698

Comment [u46]: Same to the above comment.

	95	8	1		4	4	2	8				
North	10	14.	18.		24.	25.	26.	26.				
Western	.7	11	82	23.	77	99	19	30	25.7	23.3	17.	12.9
	43	1	2	278	7	7	5	5	79	38	941	94
North	12	16.	20.		25.	26.	26.	26.				
Southern	.5	16	82	24.	60	41	28	28	25.9	23.9	19.	14.2
	64	1	22	328	6	2	6	9	28	80	221	57
	12	15.	19.		24.	25.	26.	26.				
Central	.1	39	65	23.	30	90	28	37	25.8	23.5	18.	13.8
	13	5	2	003	7	1	9	4	47	98	657	76
	12	16.	20.		24.	25.	25.					
Southern	.7	10	57	23.	98	90	85	2.8	25.5	23.9	19.	14.6
	32	3	0	746	0	5	2	04	34	78	432	71
South	13	16.	20.		25.	25.	25.	25.				
Eastern	.8	47	46	23.	03	44	24	27	25.0	24.0	19.	15.7
	53	0	3	798	3	4	9	8	22	57	962	39
	11	13.	18.		23.	24.	25.	25.				
Eastern	.4	91	17	21.	05	78	39	01	24.8	22.7	17.	13.3
	26	4	9	291	4	9	1	3	75	37	795	93

Changes in Monthly Average Minimum Temperature per year during 1989-2019.

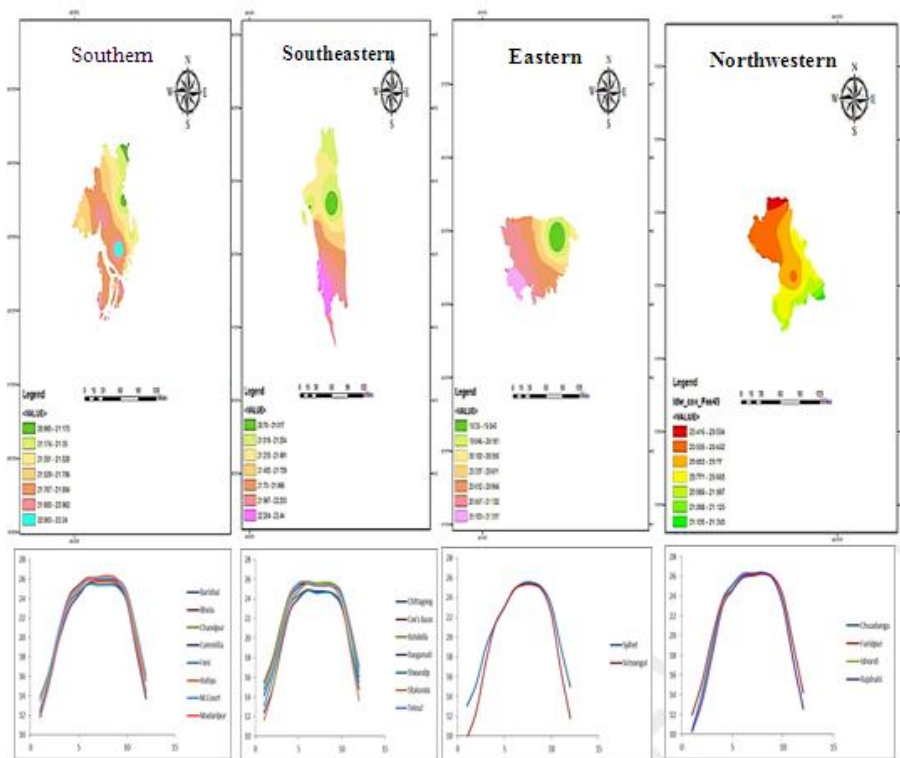
We observed that the highest change of the monthly average minimum temperature was recorded for eastern region in Bangladesh for maximum months and the lowest changes for northern region during the period of 1989-2018.

Comment [u47]: Is it so?

3.8 Visualization of average maximum and minimum temperatures for all regions

Two indications of the state of the climate are temperature and rainfall. In this article, we have displayed the mean monthly maximum and minimum temperatures as well as the typical rainfall in various parts of Bangladesh (Fig. 5(a), 5(b)). From figure 5(a), In this study period, Rajshahi, Sylhet and Dhaka all had an increase in the maximum temperature for July, and August months. In the months between September and March, the highest temperatures were in Sylhet and Chittagong. This reveals that the maximum temperatures in Sylhet, and Chittagong recent fall and winter seasons were higher. From figure 5(b), we see that for the months of July to August, the minimum temperature in Rajshahi and Dhaka climbed. It should be noted that, with the exception of May, all other months, Sylhet minimum temperatures increased. In Chittagong, the minimum temperature rose in January, April, October, and December.

Comment [u48]: It requires a detailed explanations and presentations. The figures also require readjustments and visibility issues.



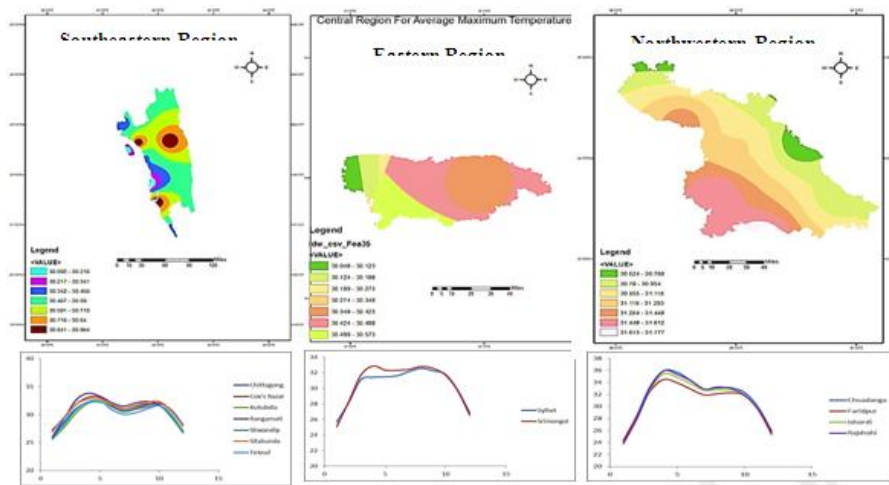


Fig 5(a): Changes in Monthly Average Maximum Temperature in 7 different regions

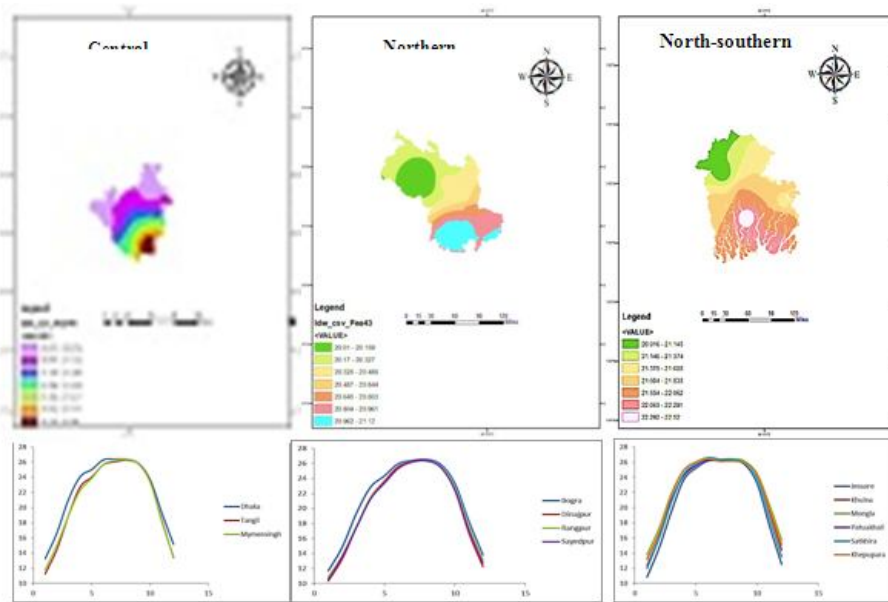


Fig 5(b): Changes in Monthly Average Minimum Temperature in 7 different regions

From figure 5(a, b), we observed that the changes of average Maximum and minimum temperature in every region and the graphical visualization shows the little changes of every meteorological stations of each region. We calculate monthly average data for maximum and minimum temperature.

4. CONCLUSION: The period 1989-2019 of all 34 meteorological stations of Bangladesh the temperature and rainfall data have been analyzed. Analysis of temperature data of all stations showed that most of the stations have increasing trends of the yearly average maximum and minimum temperature. The trends of yearly average maximum and minimum temperatures have been found to be increasing year-on-year.

Comment [u49]: Why not a space is left out here?

Comment [u50]: Check and complete the duration of the study as commented above.

Also showed increasing trend for all months except January, April and December; the increasing trend was particularly significant for the months February, March and June to September. Moreover, significant increase of maximum temperature was observed at eastern region for both yearly and monthly average data and northern region for minimum temperature. Analysis of rainfall data showed increasing trend of rainfall for majority of stations during monsoon and post-monsoon seasons, while decreasing trend of total rainfall during winter, pre-monsoon period did not show any significant change in total rainfall. In general these trends are consistent with the general climate change predictions. In view of these changes, it is necessary to regularly and systematically compile, monitor and analyze the relevant climate parameters for assessing the impacts of climate change.

REFERENCES

- [1] Chowdhury, M.H.K., and Debsarma, S.K. (1992) Climate Change in Bangladesh-A statistical review. Report of IOC-UNEP Workshop on Impacts Impacts of Sea Level Rise due to Global Warming, NOAMI, November 16-19, 1992, Dhaka, Bangladesh. Intergovernmental Oceanographic Commission.
- [2] DAS, L. C., & ZHANG, Z. (2021). ANNUAL AND SEASONAL VARIATIONS IN TEMPERATURE EXTREMES AND RAINFALL IN BANGLADESH, 1989–2018. International Journal of Big Data Mining for Global Warming, 3(01), 2150004.
- [3] Das, L. C., Mohiul Islam, A.S.M., & Ghosh. S. (2022). MANN–KENDALL TREND DETECTION FOR RAINFALL AND TEMPERATURE IN BANGLADESH. International Journal of Big Data Mining for Global Warming, 4(01), 2250001.
- [4] Debsarma, S.K. (2003) Intra-annual and inter-annual variation of rainfall over different regions of Bangladesh. In: Proceedings of SAARC Seminar on Climate Variability in the South Asian Region and its Impacts, SMRC, December 20-24, 2002, Dhaka, Bangladesh. SAARC Meteorological Research Centre.

Comment [u51]: Is it a standard citation of the references? They lack uniformity among the list of references. Why sequential numbers are required unless they are the requirements and if they are requirements, then it is not necessary to write both the number and the authors at once. So, it requires serious rework.

- [5] Harmeling, S. (2008) Global Climate Risk Index 2009, Weather-related loss and Their Impacts on Countries in 2007 and in a Long Term Comparison. Kaiserstr 201, Bonn, German Watch e.V., pp. 5-8.
- [6] IPCC(2007) Summary for Policymakers. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Avert, K.B., Tignor, M., and Miller, H.L. eds. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA, Cambridge University Press.
- [7] IPCC 2007 Climate change (2007) climate change impact, adaptation and vulnerability. Working Group II Contribution to the Intergovernmental Panel on Climate Change, Fourth Assessment Report, Summary for Policymakers, 23
- [8] Karmakar, S., and Nessa, J. (1997) Climate change and its impacts on natural disasters and south-west monsoon in Bangladesh and the Bay of Bengal. Journal of Bangladesh of Academy of Sciences, 212(2), pp. 127-136.
- [9] Karmakar, S., and Shrestha M.L. (2000) Recent Climate Change in Bangladesh. SMRC Series, no. 4. Dhaka, SAARC Meteorological Research Centre.
- [10] Karmakar S.(2003) Trends in the annual frequency of cyclonic disturbances and storms in the Bay of Bengal. In: Proceedings of SAARC Seminar on Climate Variability in the South Asian Region and its Impacts, SMRC, December 20-24, 2002, Dhaka, Bangladesh. Dhaka, SAARC Meteorological Research Centre.
- [11] Modarres, R. and da Silva, V.P. (2007) Rainfall trends in arid and semi-arid regions of Iran. Journal of Arid Environments,70, 344-355.
- [12] Mia, N.M. (2003) Variations of temperature in Bangladesh. In: Proceedings of SAARC Seminar on Climate Variability in the South Asian Region and its Impacts, SMRC, December 20-24, 2002, Dhaka, Bangladesh. Dhaka, SAARC Meteorological Research Centre.
- [13] Titumir, R.A.M., and Basak, J.K. (2012) Effects of Climate Change on Crop Production and Climate Adaptive Techniques for Agriculture in Bangladesh. Social Science Review, The Dhaka University Studies, Part-D, 29(1), PP. 215-232.
- [14] Warrick, R. A., Bhuiya, A.H., and Mirza, M. Q. (1994) The Greenhouse Effect and Climate Change: Briefing Document No.1.

Dhaka, Bangladesh Unnayan Parishod (BUP), pp. 17-20.

- [15] Webber, J. and Hawkins, C. (1980). *Statistical Analysis application to Business and Economics*. New York: Harper and Row.

UNDER PEER REVIEW