*International Journal of Environment and Climate Change*

***Volume 12, Issue 12, Page 693-708, 2022; Article no.IJECC.94500***
***ISSN: 2581-8627***
*(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)*

# Analysis of Spatially Distributed Monthly Rainfall and Temperature over Bangladesh from 1989 to 2019

**A. S. M. Mohiul Islam [a], Md. Habibur Rahman [a*], Farjana Sultana [b] and Mohammad Sariful Hasan [a]**

*[a] Department of Mathematics, University of Chittagong, Chittagong-4331, Bangladesh.*
*[b] Department of Meteorology, Assistant Meteorologist, Dhaka, Bangladesh.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/IJECC/2022/v12i121505

**Open Peer Review History:**
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/94500

***Original Research Article***

***Received: 03/10/2022***
***Accepted: 06/12/2022***
***Published: 16/12/2022***

## ABSTRACT

In this study, based on the analysis of historical data on temperature and rainfall recorded at 34 meteorological stations, It is 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.

**Corresponding author: E-mail: mdhabiburrahman1216@gmail.com;*

*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 quantities over a period of time ranging from months or millions of year (IPCC)" [1]. "The fourth Assessment report of [2] 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 0.025ºC and 0.018ºC per year by Das & Zhang [3]. Warrick et al [4], Karmakar & Shrestha [5] and Debsarma [6] provided assessment of changes in temperature and rainfall over Bangladesh, while Chowdhury & Debsarma [7] and Mia [8] reported changes in temperature based on analysis of historical data of some selected weather stations in Bangladesh, Karmakar & Nessa [9] and Karmakar [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 parameter determine the environmental condition of the particular region which affects the agricultural productivity" [11-13].

"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)" [14]. "Nevertheless, many regions of this country remain outside the ambit of climate change related actions" (Titumir & Basak) [15]. Das, Islam & Ghosh [16] showed that, "in Bangladesh January is the coldest month and April is the hottest month, where the average temperature is 18ºC and 28ºC respectively". Modeling studies by Haque et al. (1992) calculated "the increasing temperature for the projected years of 2030 and 2075 would be 1.3ºC and 2.6ºC respectively".

## 2. 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 Fig. 1. Among them Bogra, Dinajpur, Rangpur and sayedpur were selected for Nothern region, Chuadanga, Faridpur, Ishurdi and Rajshahi were sleeted 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.

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

### 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,

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}$$

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

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|y_i - \hat{y}_i|$$

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

$$MAPE = \left(\frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - \hat{y}_i}{y_i}\right|\right) \times 100\%$$

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. RESULTS 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, [17]. 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 [18].

### 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, 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 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.

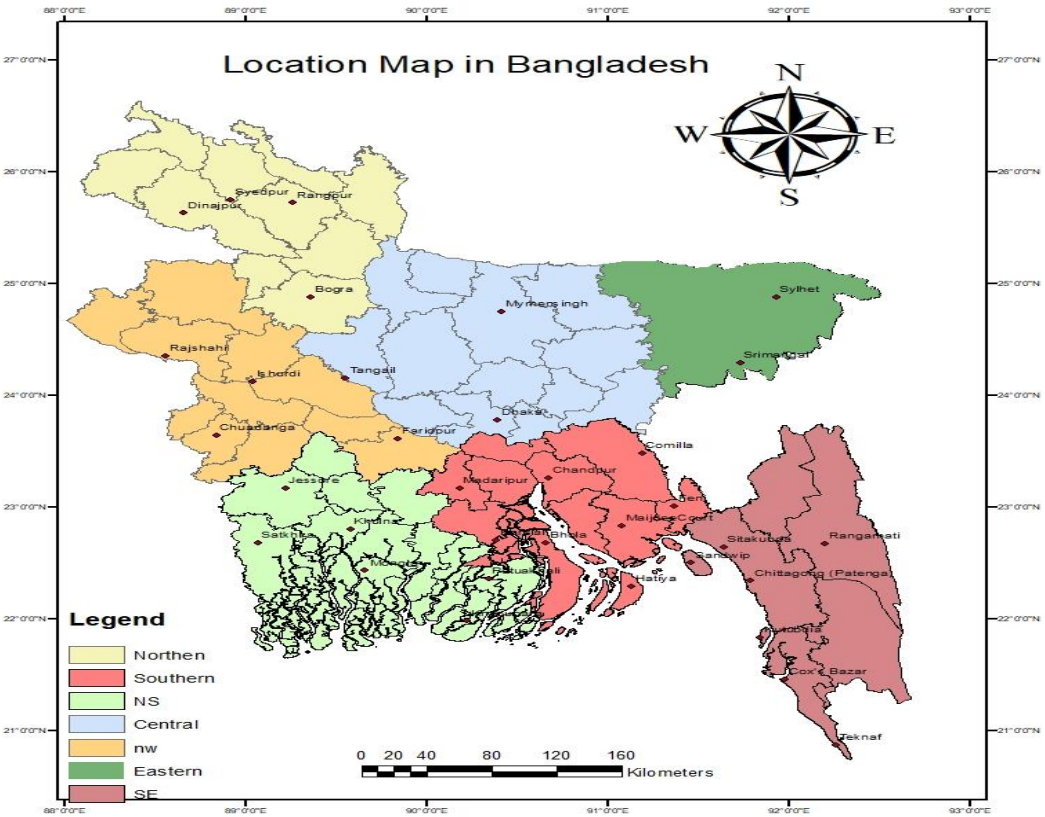



**Fig. 1. Location map of the study area**

**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 |
| North Western | 0.407 | 2.867 | 8.651 | 2.401 |
| North Southern | 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 |
| South Eastern | 0.449 | 5.484 | 18.882 | 4.664 |
| Eastern | 0.602 | 9.777 | 16.263 | 3.461 |

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 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.

## 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.

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

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

**Maximum high and low temperature:** The period 1989-2019 of all 34 meteorological stations of Bangladesh the temperature data have been analyzed. Analysis of temperature data and rainfall data of all stations showed that most of the stations have increasing trends of the yearly average maximum and minimum temperature. Prior to analysis, the station data were checked for any potential temporal discontinuities and inconsistencies. To determine the changes of maximum and minimum temperature from monthly and yearly average maximum temperature data for the period January, 1989 to December, 2019. The yearly average maximum high temperature were 30.943ºC, 32.122ºC, 31.993ºC, 31.3480ºC, 31.464ºC, 27.670ºC and 31.545ºC yearly and average maximum low temperature were 29.546ºC, 30.245ºC, 30.545ºC, 29.721ºC, 29.844ºC, 29.600ºC, 29.497ºC, for Northern, North-Western, North-southern, Central, Southern, Southeastern and Eastern region respectively high and maximum low temperature were 32.122ºC and 29.497ºC.

## 3.3 Average Minimum High and Low Temperature

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

**Average maximum temperature:** Changes in Monthly Average Maximum Temperature per year during 1989-2019.

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, got changes of monthly average minimum temperature.

**Average minimum temperature:** Changes in Monthly Average Minimum Temperature per year during 1989-2019.

It is also noticed 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 1989-2019.

**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 |
| 7 | Ishurdi | Northwestern | 24°12' | 89°06' | 21.478 | 31.920 | 1989-2019 |
| 8 | Rajshahi | Northwestern | 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 |

| No | Station name | Climate region | latitude (N) | Longitude (E) | Minimum (temperature) | Maximum (temperature) | Period of record used |
|---|---|---|---|---|---|---|---|
| 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 |

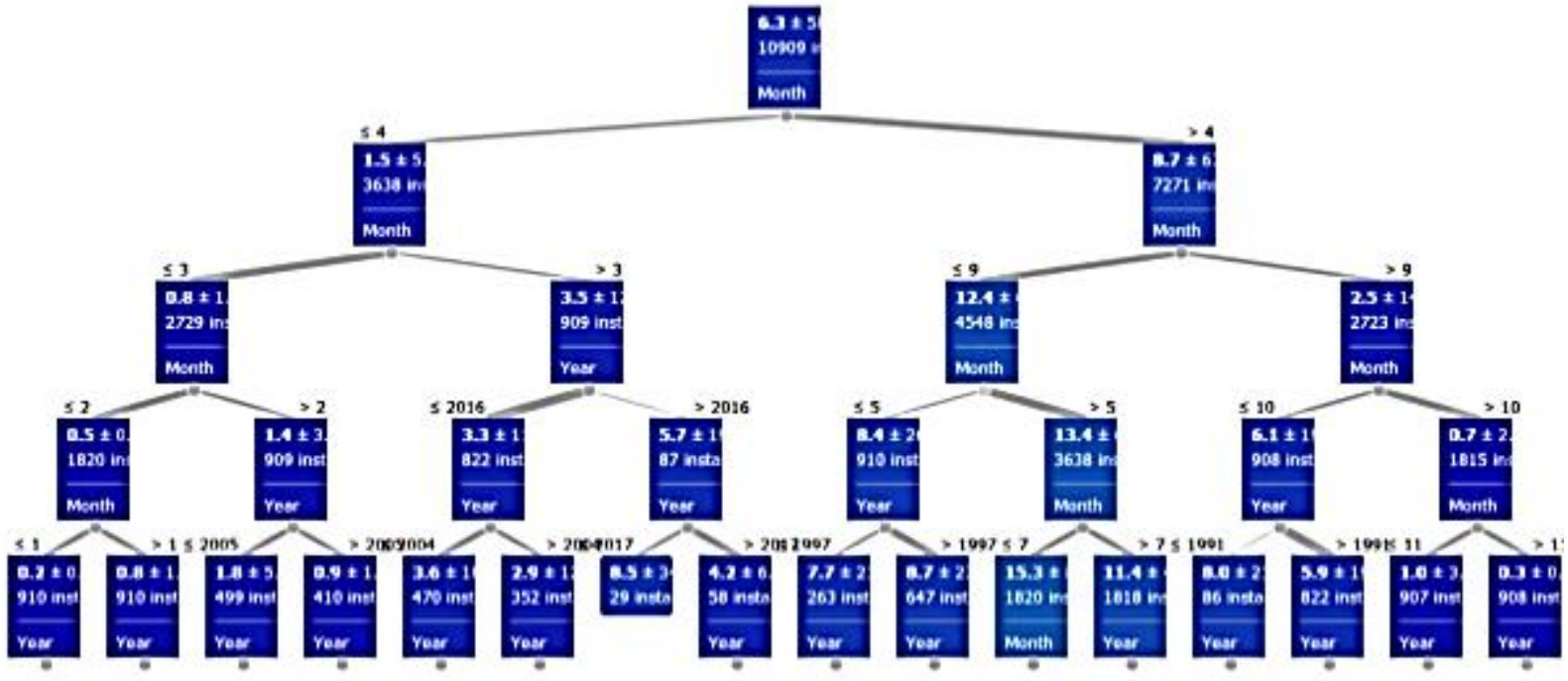
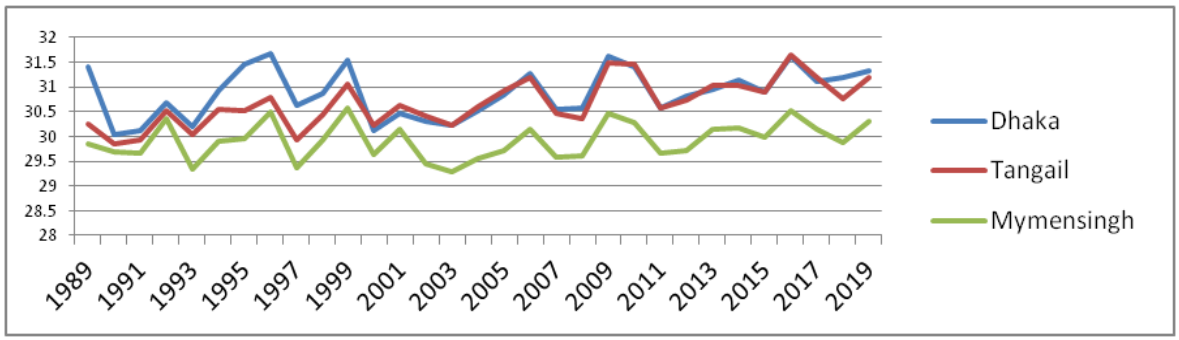
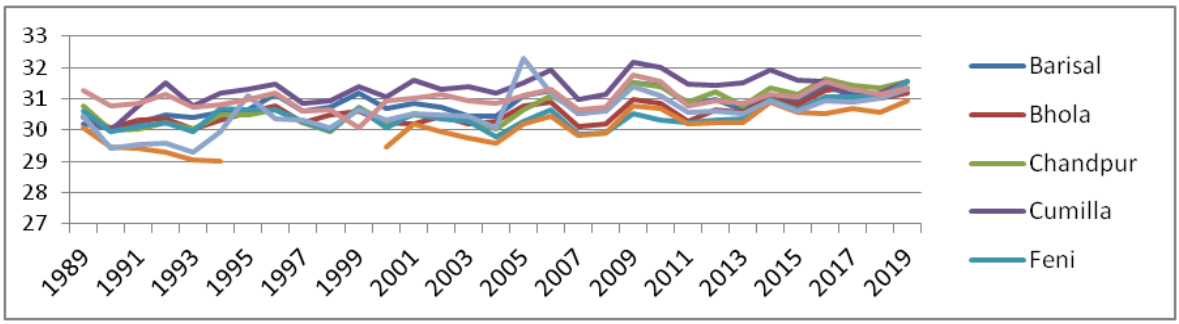
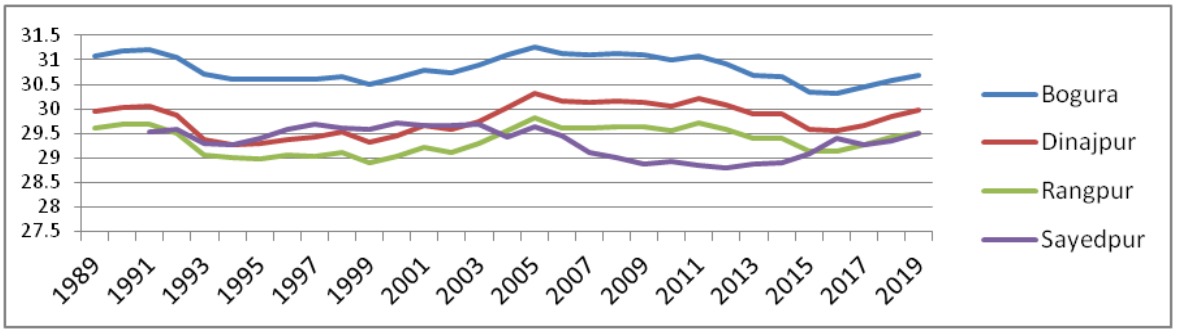
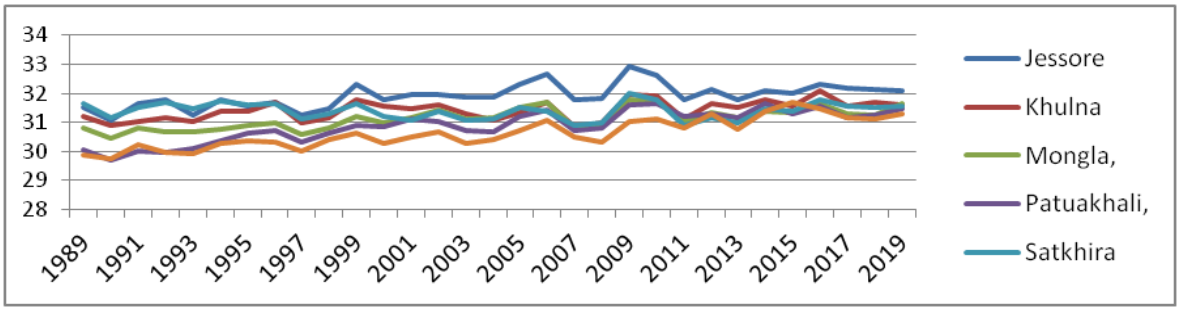


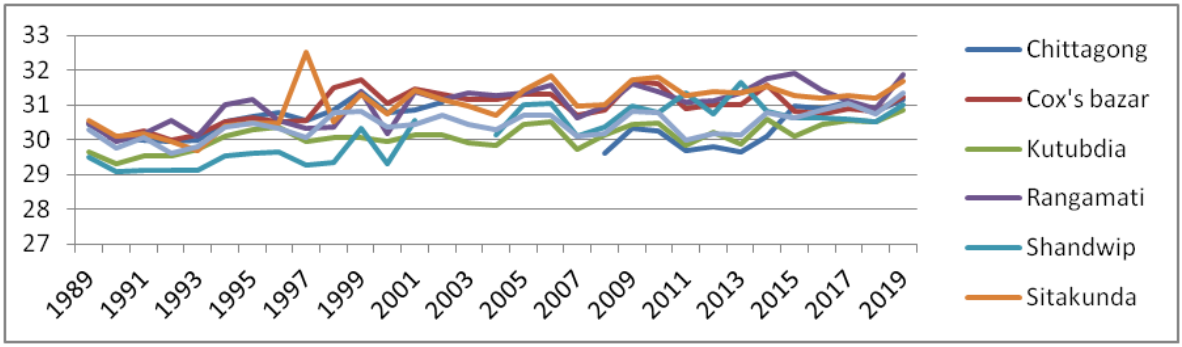

**Fig. 2. Rainfall forecast result using DT compared with observed value**


32
31.5
31
30.5
30
29.5
29
28.5
28
1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019
Dhaka
Tangail
Mymensingh


33
32
31
30
29
28
27
1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019
Barisal
Bhola
Chandpur
Cumilla
Feni


31.5
31
30.5
30
29.5
29
28.5
28
27.5
1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019
Bogura
Dinajpur
Rangpur
Sayedpur


34
33
32
31
30
29
28
1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019
Jessore
Khulna
Mongla,
Patuakhali,
Satkhira


33
32
31
30
29
28
27
1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019
Chittagong
Cox's bazar
Kutubdia
Rangamati
Shandwip
Sitakunda

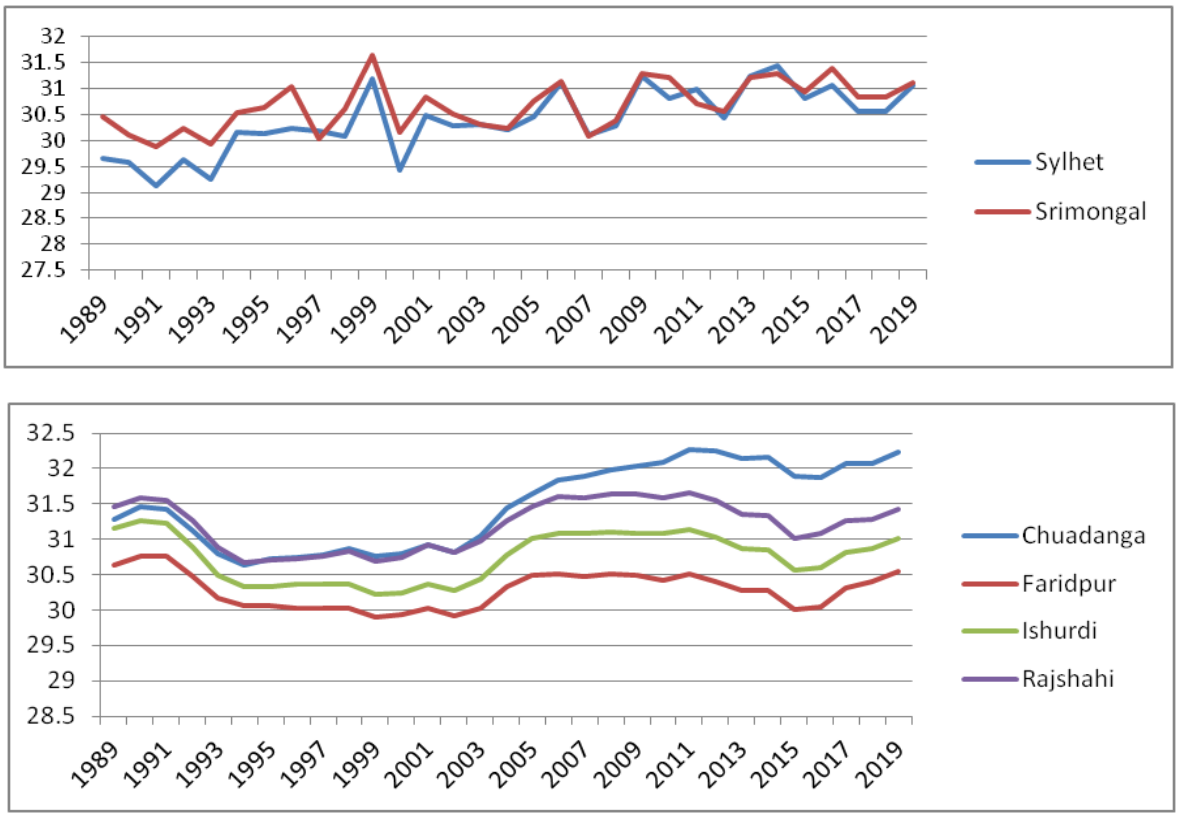
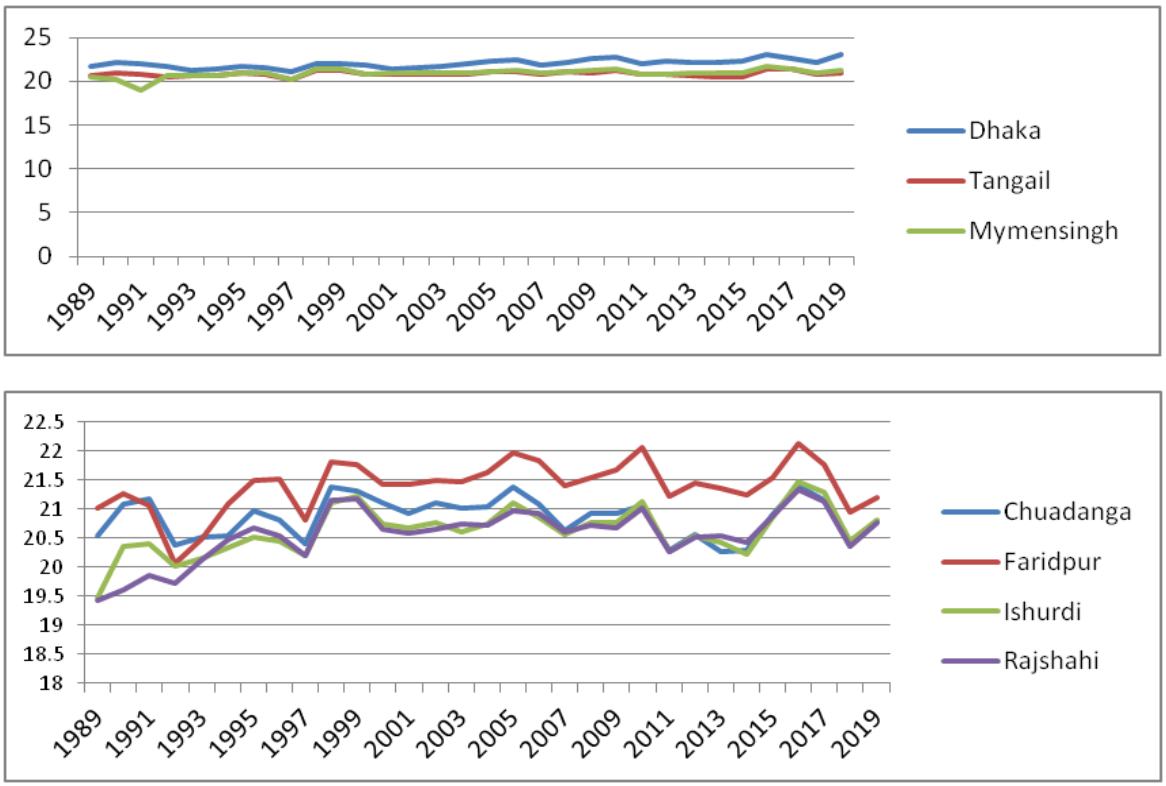
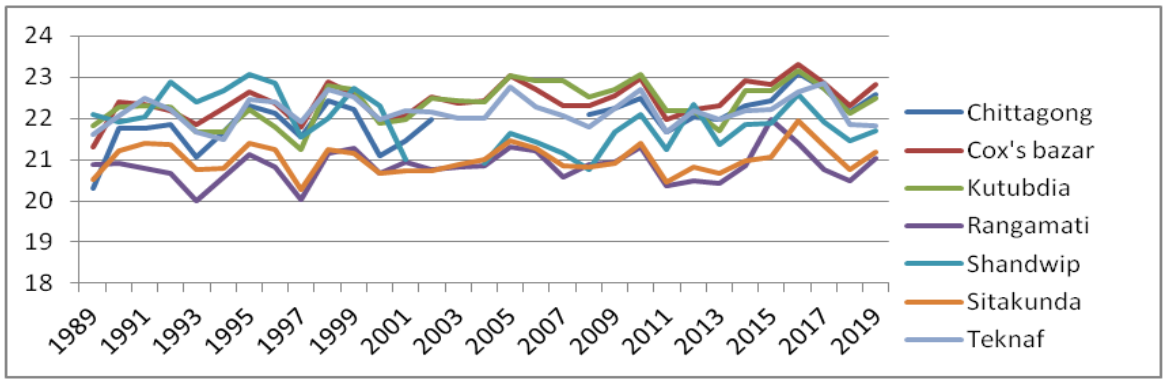
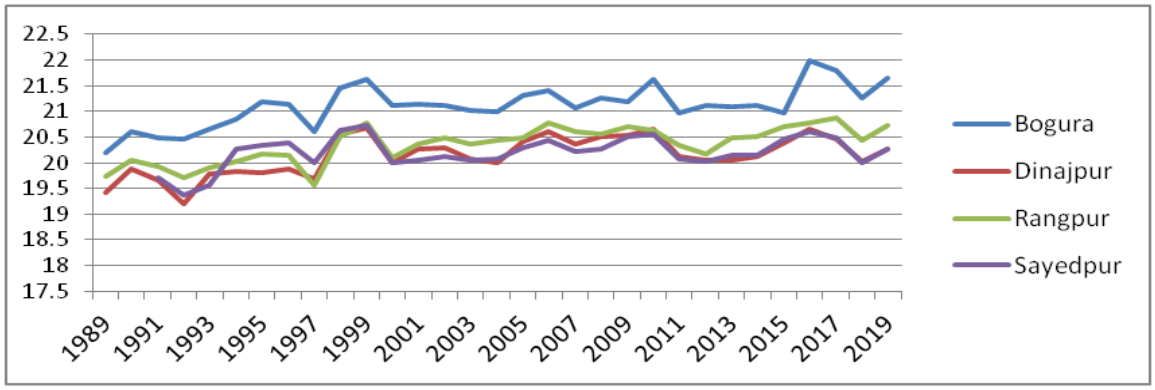
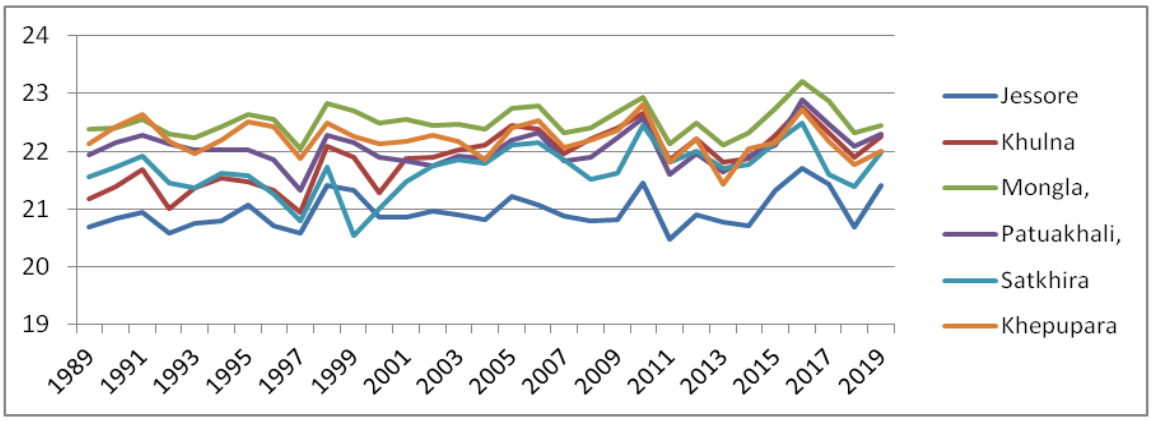


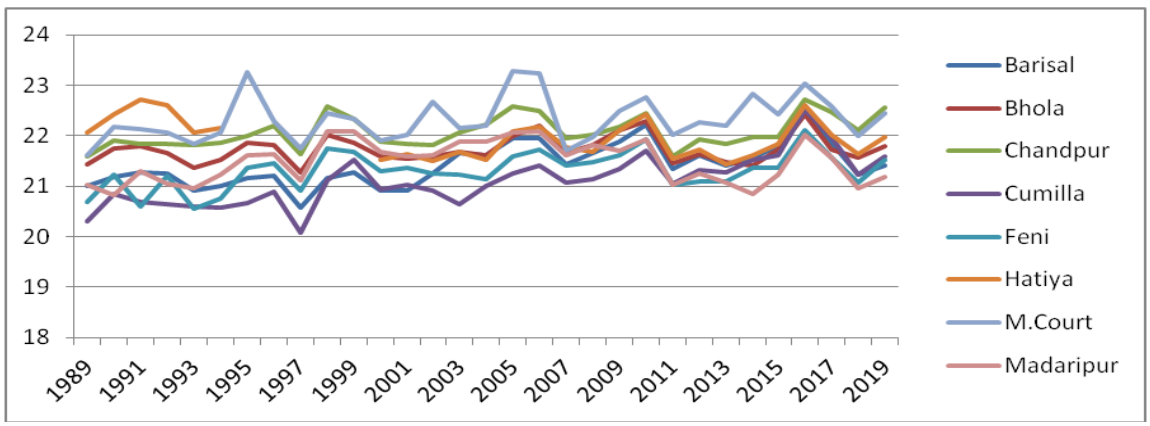

**Fig. 3. Yearly average maximum high and low temperature changed at different region in Bangladesh**




24
23
22
21
20
19
18
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
Chittagong
Cox's bazar
Kutubdia
Rangamati
Shandwip
Sitakunda
Teknaf


22.5
22
21.5
21
20.5
20
19.5
19
18.5
18
17.5
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
Bogura
Dinajpur
Rangpur
Sayedpur


24
23
22
21
20
19
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
Jessore
Khulna
Mongla,
Patuakhali,
Satkhira
Khepupara


24
23
22
21
20
19
18
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
Barisal
Bhola
Chandpur
Cumilla
Feni
Hatiya
M.Court
Madaripur

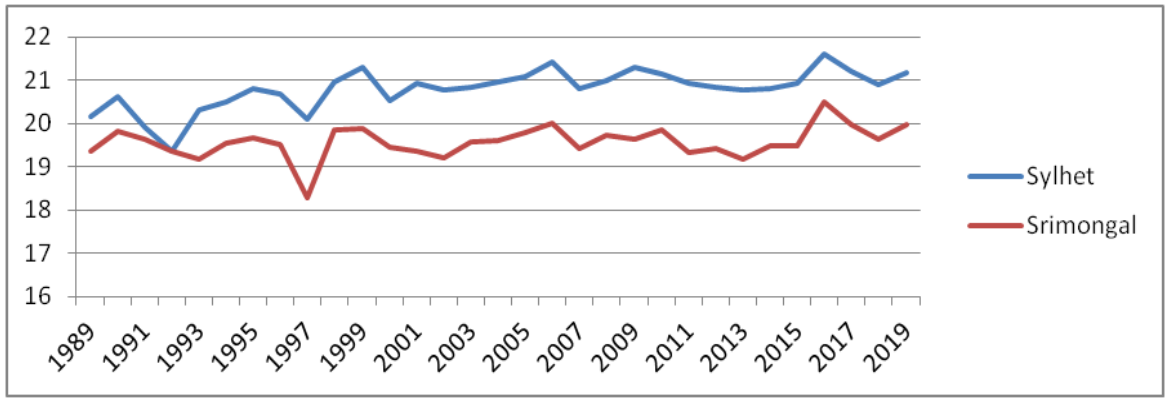


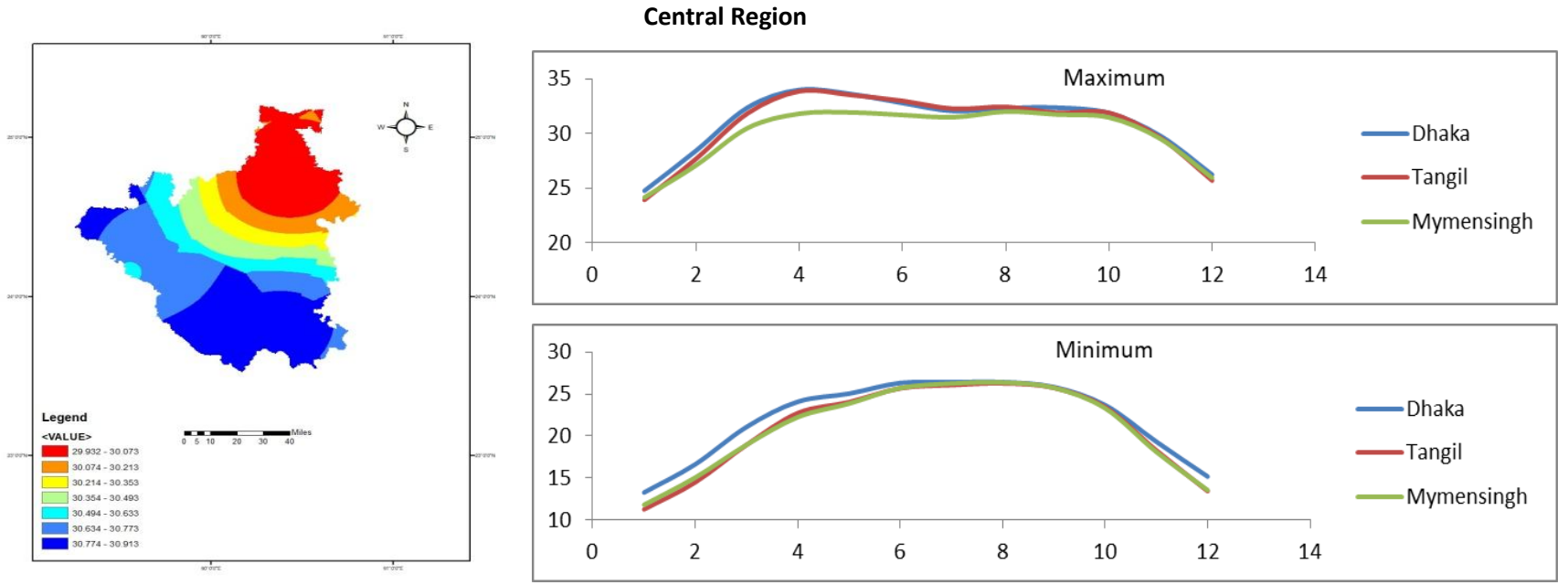

**Fig. 4. Yearly average minimum high and low temperature changed at different region in Bangladesh**

**Table 3. Monthly average maximum temperature from 1989-2019**

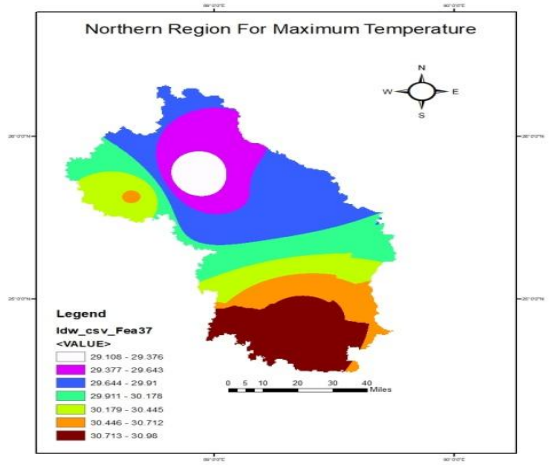
| Month | Jan | Feb | Mar | Apr | May | June | July | August | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northern | 22.798 | 26.444 | 30.359 | 31.743 | 32.226 | 32.146 | 31.785 | 32.131 | 31.722 | 30.924 | 28.893 | 25.097 |
| Northwestern | 24.089 | 28.153 | 32.961 | 35.454 | 34.945 | 33.826 | 32.603 | 32.825 | 32.497 | 31.694 | 29.384 | 25.522 |
| North | 25.438 | 29.046 | 32.812 | 34.459 | 34.638 | 33.125 | 31.949 | 31.896 | 32.343 | 31.909 | 29.972 | 26.687 |
| Southern Central | 24.262 | 27.714 | 31.564 | 33.215 | 30.011 | 32.483 | 31.923 | 32.229 | 32.172 | 31.736 | 29.614 | 25.944 |
| Southern | 25.193 | 28.340 | 31.549 | 32.965 | 33.140 | 31.993 | 31.400 | 31.703 | 31.867 | 31.681 | 30.048 | 26.539 |
| South | 26.765 | 28.891 | 31.534 | 32.426 | 32.699 | 31.572 | 30.794 | 31.233 | 31.718 | 31.666 | 30.243 | 27.336 |
| Eastern Eastern | 25.369 | 28.249 | 31.395 | 32.120 | 31.912 | 31.946 | 32.291 | 32.656 | 32.379 | 31.716 | 29.702 | 28.254 |

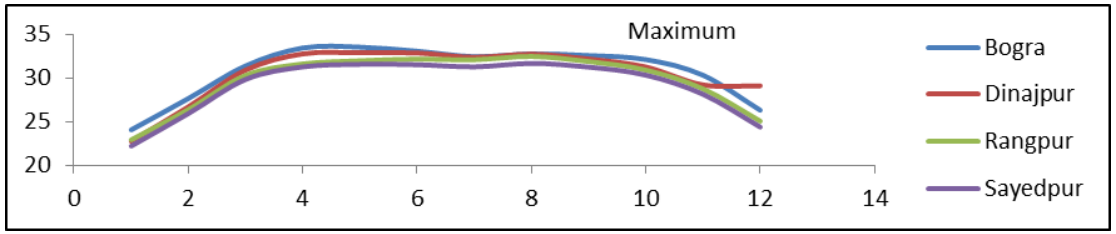
**Table 4. Monthly average minimum temperature from 1989-2019**

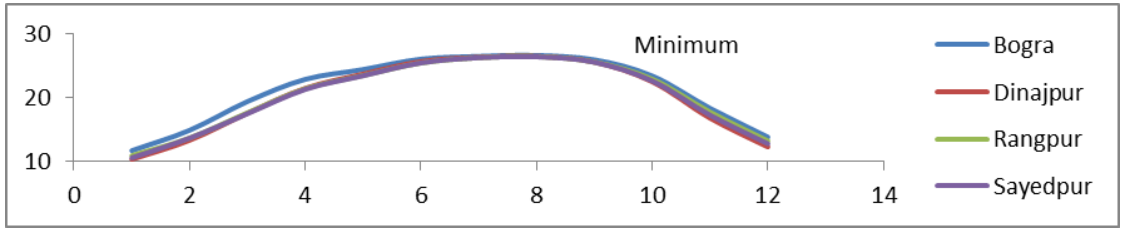
| Region | Jan | Feb | Mar | April | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northern | 10.695 | 13.638 | 17.681 | 21.188 | 23.314 | 25.174 | 25.852 | 25.998 | 24.994 | 22.295 | 17.136 | 12.698 |
| North Western | 10.743 | 14.111 | 18.822 | 23.278 | 24.777 | 25.997 | 26.195 | 26.305 | 25.779 | 23.338 | 17.941 | 12.994 |
| North Southern | 12.564 | 16.161 | 20.8222 | 24.328 | 25.606 | 26.412 | 26.286 | 26.289 | 25.928 | 23.980 | 19.221 | 14.257 |
| Central | 12.113 | 15.395 | 19.652 | 23.003 | 24.307 | 25.901 | 26.289 | 26.374 | 25.847 | 23.598 | 18.657 | 13.876 |
| Southern | 12.732 | 16.103 | 20.570 | 23.746 | 24.980 | 25.905 | 25.852 | 2.804 | 25.534 | 23.978 | 19.432 | 14.671 |
| South Eastern | 13.853 | 16.470 | 20.463 | 23.798 | 25.033 | 25.444 | 25.249 | 25.278 | 25.022 | 24.057 | 19.962 | 15.739 |
| Eastern | 11.426 | 13.914 | 18.179 | 21.291 | 23.054 | 24.789 | 25.391 | 25.013 | 24.875 | 22.737 | 17.795 | 13.393 |

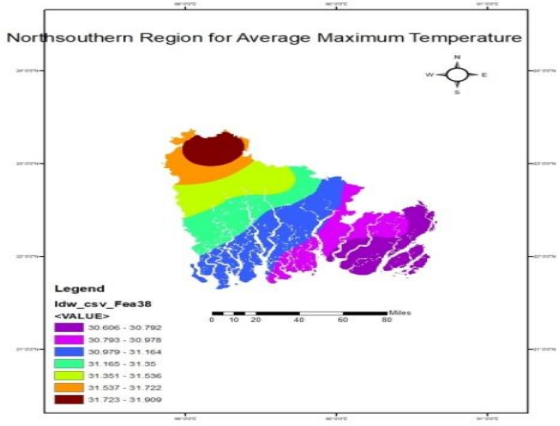


**Northern Region**

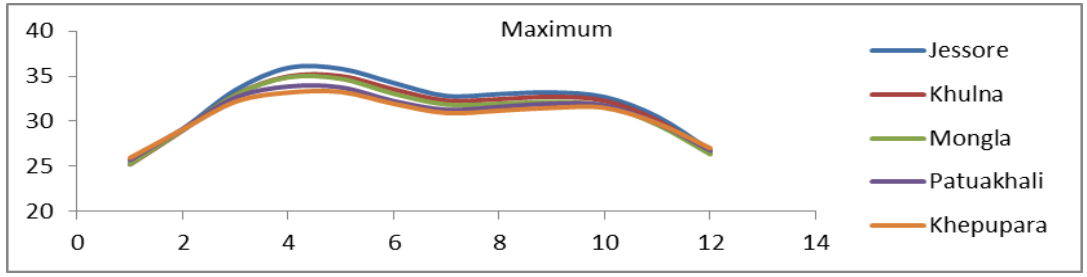


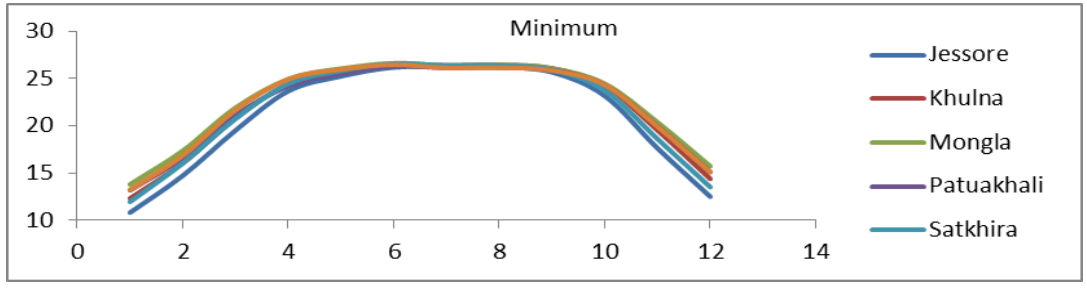



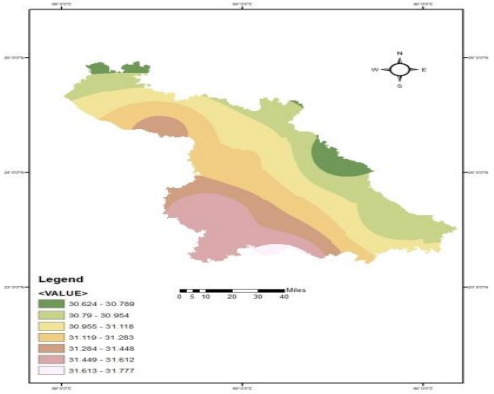



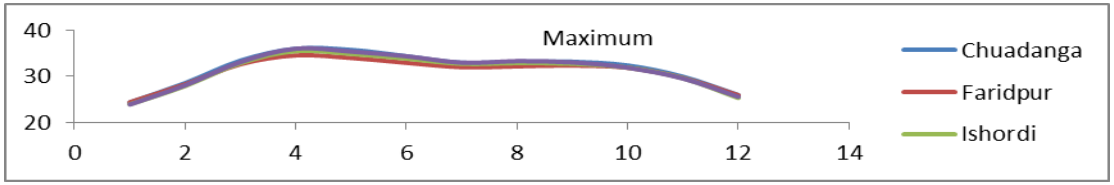

**North-Southern Region**

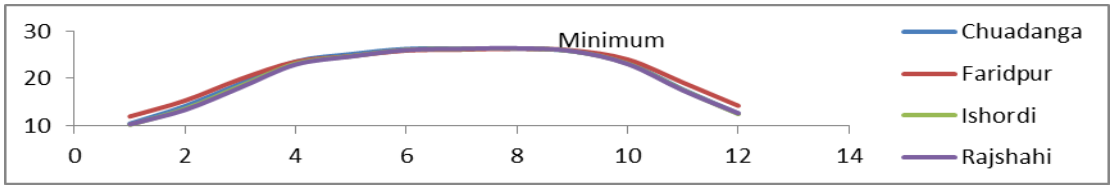


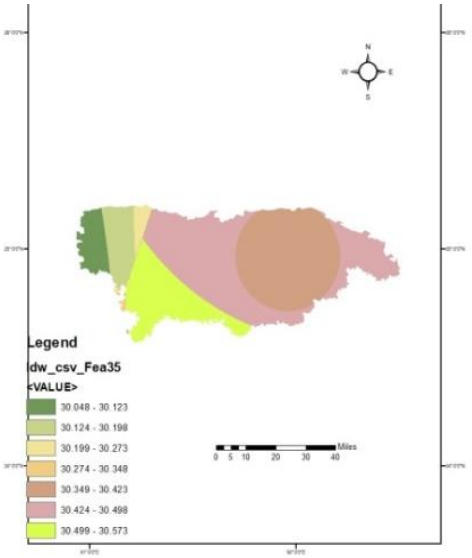



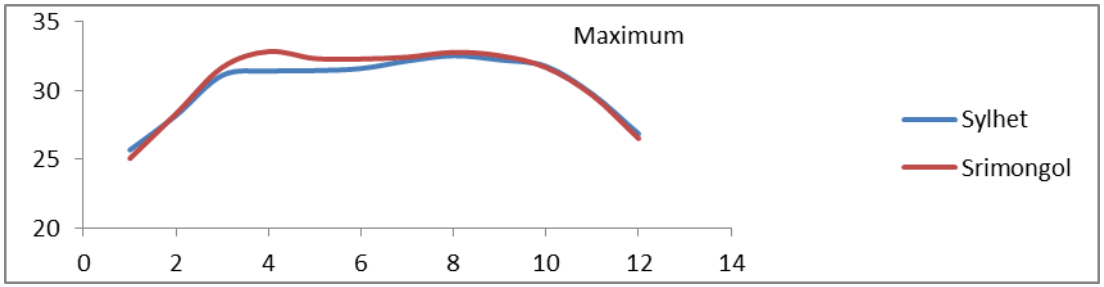
**North Western Region**

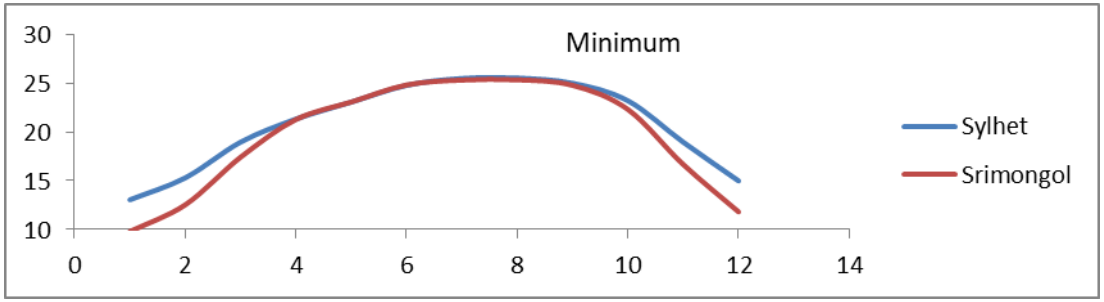



**Eastern Region**

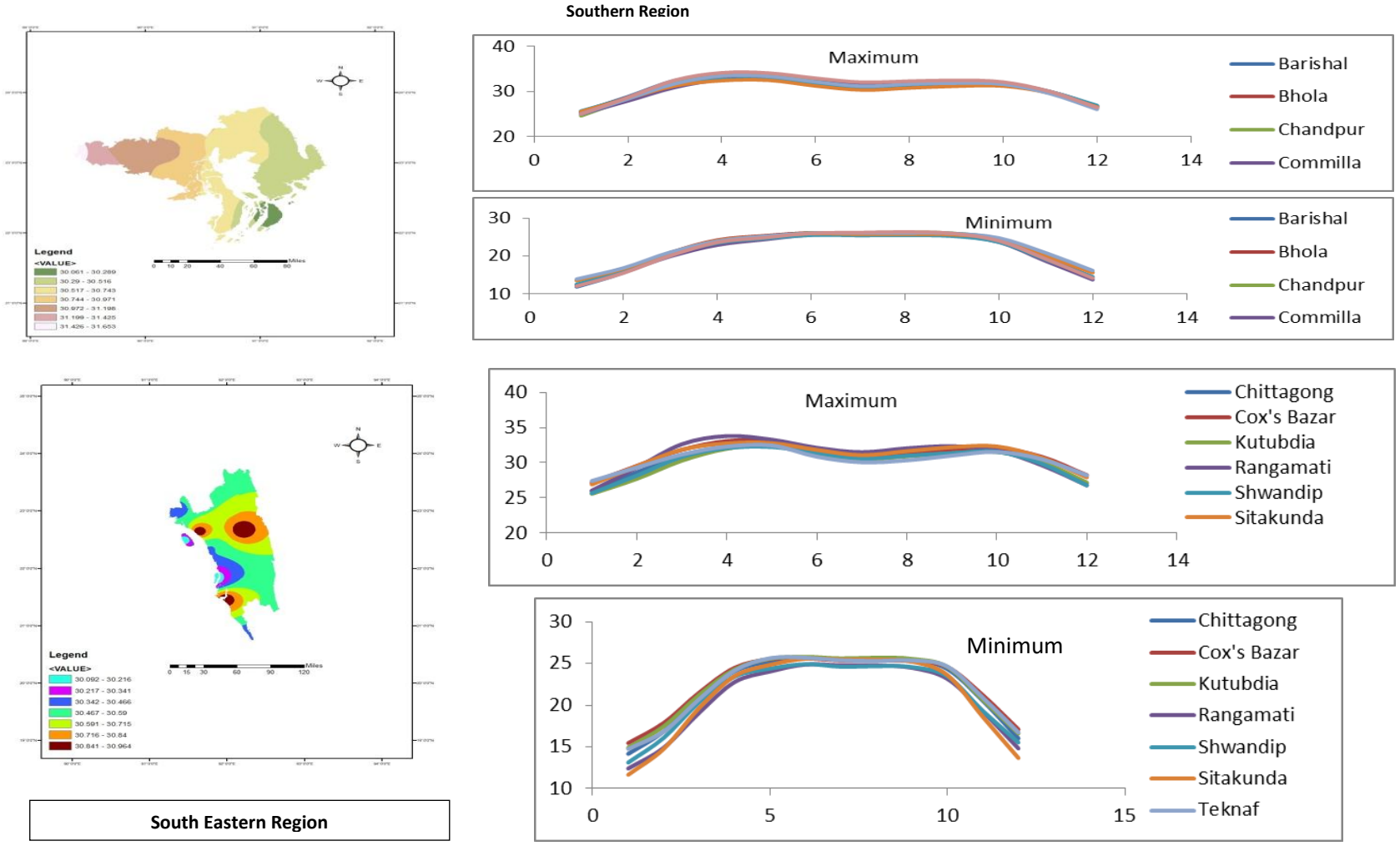



**Fig. 5. Changes in monthly average maximum and minimum temperature in 7 different regions**

### 3.4 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, It has been displayed the mean monthly maximum and minimum temperatures as well as the typical rainfall in various parts of Bangladesh (Fig. 5). From Fig. 5, 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 Fig. 5, 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.

From Fig. 5, it is observed that the changes of average Maximum and minimum temperature in every region and the graphical visualization shows the little changes of every meteorological station of each region. It's calculates 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. 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.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. 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; 2007.
2. IPCC 2007 Climate change. Climate change impact, adaptation and vulnerability. Working Group II Contribution to the Interogovernmental Panel on Climate Change, Fourth Assessment Report, Summary for Policymakers. 2007;23.
3. Das LC, Zhang Z. Annual and seasonal variations in temperature extremes and rainfall in Bangladesh. 1989–2018. International Journal of Big Data Mining for Global Warming. 2021;3(01):2150004.
4. Warrick RA, Bhuiya AH, Mirza MQ. The greenhouse effect and climate change: Briefing Document No.1. Dhaka, Bangladesh Unnayan Parishod (BUP). 1994;17-20.
5. Karmakar S, Shrestha ML. Recent climate change in Bangladesh. SMRC Series, no. 4. Dhaka, SAARC Meteorological Research Centre; 2000.
6. Debsarma SK. 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; 2003.
7. Chowdhury MHK, Debsarma SK. 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; 1992.

8. Mia NM. 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; 2003.
9. Karmakar S, Nessa J. 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, 1997;212(2): 127-136.
10. Karmakar. 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; 2003.
11. Modarres R, da Silva VP. Rainfall trends in arid and semi-arid regions of Iran. Journal of Arid Environments. 2007;70: 344-355.
12. Kulsum Umme, Md Moniruzzaman. Exploring the relationship of climate change and land-use dynamics with satellite-derived surface indices and temperature in greater Dhaka, Bangladesh. Journal of Earth System Science. 1980; 131.2(2022):1-15.
13. Chowdhury, Tahmid Anam, Md Saiful Islam. Assessing and simulating impacts of land use land cover changes on land surface temperature in Mymensingh City, Bangladesh: 10.32526/ennrj/20/ 202100110. Environment and Natural Resources Journal. 1980;20.2(2022): 110-128.
14. Harmeling S. Global climate risk index 2009, weather-related loss and their impacts on countries in 2007 and in a comparison. Kaiserstr 201, Bonn, German Watch E.V. 2008;5-8.
15. Titumir RAM, Basak JK. Effects of climate change on crop production and climate adaptive techniques for agriculture in Bangladesh. Social Science Review, The Dhaka University Studies, Part-D. 2012; 29(1):215-232.
16. Das LC, Mohiul Islam ASM, Ghosh S. Mann–kendall trend detection for rainfall and temperature in Bangladesh. International Journal of Big Data Mining for Global Warming. 2022;4(01), 2250001.
17. Webber J, Hawkins C. Statistical analysis application to business and economics. New York: Harper and Row; 1980.
18. Wu Yichen et al. Statistical learning-based spatial downscaling models for precipitation distribution. Advances in Meteorology. 2022;1980.



*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*https://www.sdiarticle5.com/review-history/94500*