British Journal of Applied Science & Technology
20(5): 1-13, 2017; Article no.BJAST.32632
ISSN: 2231-0843, NLM ID: 101664541

SCIENCEDOMAIN ***international***
www.sciencedomain.org

The Variability of the Historical and Future Temperature in Bangladesh

M. M. Hossain[1*], E. Hasan[1] and M. Alauddin[1]

[1]Department of Civil Engineering, Dhaka University of Engineering and Technology, Gazipur, Bangladesh.

This work was carried out in collaboration between all authors. Author MMH designed the study, performed the statistical analysis with the collaboration of Author EH wrote the protocol and the first draft of the manuscript. Authors MMH and EH managed the analyses of the study. Author MA managed the literature searches and took part in the model calibration. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2017/32632
Editor(s):
(1) João Miguel Dias, Habilitation in Department of Physics, CESAM, University of Aveiro, Portugal.
Reviewers:
(1) Agu Eensaar, Tallinn University of Applied Sciences, Estonia.
(2) Kuti Ibrahim Abayomi, Federal University of Technology Minna, Nigeria.
(3) Odiana Sylvester, University of Benin, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/18953

Original Research Article

Received 6th March 2017
Accepted 2nd May 2017
Published 6th May 2017

ABSTRACT

Aims: To discern how the historical temperature varied over the time period from 1975 to 2014 and what kind of temperature profile Bangladesh may prevail in the future.
Study Design: This study was designed to reveal how the monthly mean of the daily average, monthly mean of daily maximum and monthly mean of the daily minimum temperature of all divisions covering all hydrological units of Bangladesh changed historically. It is also designed to forecast the all type of temperatures up to 2050 using Box Jenkin's algorithm in IBM SPSS.
Place and Duration of Study: This study was conducted within the time period from December 2015 to December 2016 under the Department of Civil Engineering, Dhaka University of Engineering & Technology, Gazipur, Bangladesh.
Methodology: At first the daily average, daily minimum and daily maximum temperature for the time period 1975 to 2014 of 13 stations, covering all hydrological units of Bangladesh, were converted in to monthly mean and then graphs of individual months were plotted and analyzed afterwards. To infer the historical temperature variations clearly over the entire time period, histogram of the decadal averages of the each type of temperature of the individual months were

---

**Corresponding author: E-mail: monowar84@duet.ac.bd;*

also plotted. Finally, the monthly records were forecasted up to 2050 by a time series model using Box Jenkin's algorithm in IBM SPSS.

Results: Based on the historical and projected temperature, this study revealed that winter became colder especially in January and the summer got hotter over the time which may continue in future. By 2050 the maximum temperature may rise by 1.50±0.3℃ in summer, average temperature may rise by 1.0±0.3℃ and minimum temperature may vary by -0.8±0.3℃ in winter.

Conclusion: This study concludes that winter may get colder in the northern part as well as some southern part of Bangladesh and reverse may suit for the summer where January and April would be the coldest and the hottest months respectively in future. By the year 2050, the average temperature may rise by 1.0±0.3℃ and the maximum temperature may lead by 1.50±0.3℃, whereas the minimum temperature may vary by 0±0.2℃. Overall, Bangladesh would experience a comparatively warmer weather in the coming decades.

Keywords: Mean; maximum; minimum; temperature; IBM SPSS; ARIMA and projection.

1. INTRODUCTION

Climate change and global warming are major concerns across the world as the mean surface temperature is soaring up day by day. According to Inter- governmental Panel on Climate Change (IPCC), the global surface temperature increase by the end of the 21st century is likely to exceed 1.5℃ relative to the 1850 to 1900 period for most scenarios, and is likely to exceed 2.0℃ for many scenarios [1]. World Bank report argued that Bangladesh is the most vulnerable country in the south Asia by the expected 2℃ rise in World's average temperature in next decades [2] and due to its geographical location this country will also be affected in many ways [3-5]. By this time Bangladesh has already been experienced many climatic extremes such as droughts, floods, cyclones and salinity intrusions [6]. Though Bangladesh is a small country, it has different hydrological and meteorological characters of its different parts that show the temporal and spatial variations. In summer the temperature varies from 30℃ to 40℃ and in winter temperature falls to 10℃ and sometimes even get lower [7].

Bangladesh mainly depends on agriculture for her economy as agriculture is the mainstay of Bangladesh's economy. Agriculture comprises about 15% of the country's GDP and 60% of the total labor force. Temperature is one of the most important climatic parameters, that is greatly related with the agriculture of Bangladesh. High temperature has already affected this country in many ways [8] and it will keep affecting significantly the Bangladesh agriculture especially crop production [9-12], human health [13-15] and also other related fields.

Every crop has specific temperature range for their vegetative and reproductive growth and the production faces constraints when the temperature falls below or exceeds the range. Higher temperature may affect the production of rice, wheat, tomato seriously [16-18] and it has negative effects on the soil organic also. In case of human health, both low and high temperatures affect in different dimensions. For instance, low temperature causes infant mortality in rural areas [19] and high temperature causes infectious diseases [20]. To take the preventive and curative measures of the adverse effects on human health and agriculture due to temperature variations, now it has become a great question that what will be the temperature profile of Bangladesh in the future? In this regard, forecasting of temperature may play a very important role in adapting the crop production and cropping pattern with the temperature variations and also to take the preventive and curative measure for human health.

However, based on both historical and projected consequences of the incremental temperature, many researchers from in and outside of Bangladesh tried to explore how the historical temperature varied over time and what would be the future temperature scenario in Bangladesh. Depending on the research extent, methodology and used tools, different researchers came up with different outcomes. Some of the outcomes were consistent with each other while some of which did not. For instance, in Cox's Bazar and Sylhet, the maximum temperature has increased significantly by 0.021℃ per year and in case of minimum temperature the highest increase was found in Dhaka by 0.049℃ followed by Cox's Bazar (0.038℃ per year) whereas significant decrease has been observed in Rajshahi by 0.047℃ per year [21]. Based on monthly maximum temperature data during 1948 to 2010, Rahman [22] pointed out a positive trend at a rate of 0.50℃ per 100 year. The maximum increase occurred during November at a rate of 2.05℃ per 100 year. In the other research Rahman and Lateh [23] observed that in the northern, northwestern, northeastern, central and central southern parts of Bangladesh, the highest upward trend in minimum temperature ranged 0.80–2.4 ℃ was observed while greatest warming in the maximum temperature ranged of 1.20–2.48 ℃ was found in the southern, southeastern and northeastern parts during 1971–2010. Based on the data availability and the research interests, researchers studied on different kinds of temporal, spatial and seasonal variations. Some researchers also analyzed the temperature variations in the divisional areas and some specific districts or specific hydrological units only. For instance, Mohiuddin et al. [24] studied only on the Dhaka city and found that minimum average monthly temperature increased significantly and the most significant changes occurred in winter (December-February) where highest increase observed by 13.6℃ in December over the period of 100 years. On the contrary Basak et al. [25] worked on almost all available stations (34 stations) across the country and found that yearly average maximum temperature was increasing at a rate of 0.0186℃ per year, whereas the rate was 0.0152℃ per year for yearly average minimum temperature. The authors also suggested that monthly average maximum temperature showed an increasing trend for all months except January and a very significant increase was in April. The monthly average minimum temperature also showed the increasing trends for all months except January and November [25]. From the above discussion it becomes very clear that most of the researchers worked on the trend analysis of the historical temperatures but very limited research works were carried out to explore the future temperature scenarios of Bangladesh. On the contrary, some people worked only on the average or maximum or only on the minimum temperatures but studies on all type of temperatures together and their future forecasting are very rare. For this reason this study aimed to explore the future maximum, minimum and average temperatures scenario of Bangladesh based on its historical records using a time series model in SPSS by Box-Jenkin's method. To forecast the future temperature, a model must need the historical records which actuated this research to observe the historical variations in the maximum, minimum and average temperatures of different regions of Bangladesh.

2. METHODOLOGY

2.1 Data Processing and Historical Analysis

Daily average, daily minimum and daily maximum temperature (dry-bulb temperature) of 35 stations across the country were collected from the Bangladesh Metrological Department (BMD). All the temperature records were for the time period from 1975 to 2014. Based on the hydrological regions (Fig. 1.) 13 stations were selected which cover all hydrological regions as well as all divisions of Bangladesh.

Fig. 1. Hydrological regions of Bangladesh
(Source, Alam [26])

Table 1. Study area with corresponding hydrological region and number

Station	Hydrological regions (no.)
Dhaka	North central (3)
Mymensing	North East (2)
Rajshahi	North West (4)
Bogra	North West (4)
Rangpur	North West (4)
Chittagong	Eastern Hill (7)
Comilla	South East (6)
Cox's Bazar	Eastern Hill (7)
Barisal	South Central (5)
Khepupara	South Central (5)
Khulna	South West (1)
Jessore	South West (1)
Sylhet	South Central (2)

At first daily temperatures of the selected stations were converted to monthly mean of daily average, monthly mean of the daily minimum and monthly mean of the daily maximum and plotted against time of individual months afterwards.

For example, for the month January, the monthly average of the daily averages temperatures were plotted for the time period from 1975 to 2014. Then the monthly average of the daily minimum and the daily maximum temperature of the same month for the same time period were plotted. Likewise, the graphs of the monthly average of the daily averages, daily minimum and daily maximum temperatures were plotted for the months February to December for the same time period. After plotting these graphs, this study faced difficulties to provide the precise results as the all temperatures, either average or minimum or maximum, fluctuated enormously through the entire time period. To infer the historical temperature variations clearly over the entire time period, histogram of the decadal averages of the each type of temperatures of the individual months were also plotted.

2.2 Stationarity Test

Checking the stationarity of the historical temperature is the prerequisite work for choosing model type and forecasting process. In this study the stationarity tests were conducted for all the temperature types of all stations by plotting the residual Auto Correlation Function (ACF) and residual Partial Auto Correlation Function (PACF) with maximum number of lags 24 and 95% confidence interval were plotted (Fig. 2). The graphs of ACF and PACF were used as an indicator of consistency of the data. If all the spikes (Fig. 2) lied within the upper and lower boundary limits then the data were considered as consistent or stationary otherwise inconsistent. Both the consistent and inconsistent data were used in this study but handled in different ways.

2.3 Model Identification

To forecast the temperature up to 2050, a time series model was developed in IBM-SPSS using Box-Jenkins algorithm. SPSS stands for Statistical Package for Social Science (SPSS) which is a data mining and text analytics software available from IBM. It is usually used to build predictive models and conduct other analytic tasks like manipulation and managing data, calculating a wide variety of statistics and analyses with simple instructions. It has a visual interface which allows users to leverage statistical and data mining algorithms without programming.

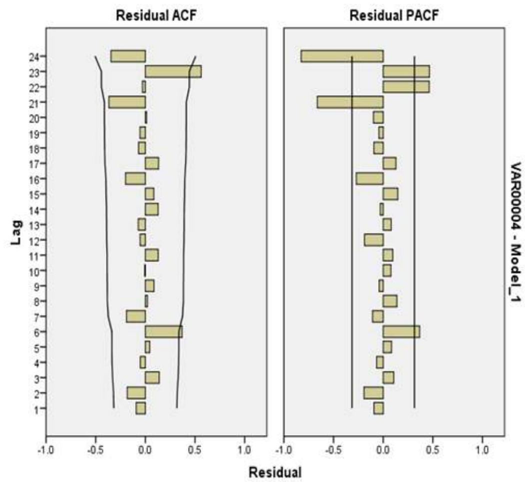

Fig. 2. Auto correlation factor and partial Auto correlation factor

This study used a time series model in IBM SPSS as the performance and validity of the model for forecasting was justified and recommended by many researchers [27–29]. However, ARIMA, Exponential Smoothing and Expert Modeler were used in this study for the forecasting but model types were chosen based on the stationarity test. In case of consistent or stationary data, at first Expert Modeler and then Exponential Smoothing option was chosen. For each execution of the model some statistical parameters; stationary R^2, R^2, Root Mean Square Error (RMSE) and normalized Bayesian information criterion (BIC), of the model were chosen to plot. When the model was run, it showed both graphical and numerical forecasted values and the forecasted values were saved along with other model statistical parameters.

In case of inconsistent data, The Box-Jenkins algorithm to modeling Auto Regression Incorporated Model Analysis (ARIMA) was chosen. ARIMA models describe the current behavior of the variables in terms of linear relationships with their past values. ARIMA model can be decomposed into two parts. First, it has an integrated (I) component (d) which represents the order of differentiating to be performed on the series to attain stationary. The second component of an ARIMA consists of an ARMA model for the series rendered stationary through differentiation. The ARMA component is further divided into AR and MA components. The Auto Regressive (AR) components capture the correlation between the current values of the time series and some of its past values. For example, AR (1) means that the current observation is correlated with its immediate past values at a time. The moving Average (MA) component represents the duration of the influence of a random shocks. For example, MA (1) means that a shock on the value of the series at time t is correlated with the shock at $\text{time} = 1$. The Auto Correlation Functions (ACF) and Partial Auto Correlation Functions (PACF) are used to estimate the values of *p* and *q*. The models were run several times on trial and error basis using different *p, d,* and *q* values until the spikes reach the boundary limits which indicates the data are stationary (Fig. 3). However, about 95 percent of the total temperature data were inconsistent where ARIMA (29, 1, 0) was used for forecasting and Exponential Smoothing and Expert modeler were used for the rest 5 percent but among these three models ARIMA (29, 1, 0) seemed the best model for the forecasting.

2.4 Forecasting the Temperatures

For the forecasting process, at first the temperatures of each month from 1975 to 2014 (for instance, monthly mean temperature of January from 1975 to 2014) were incorporated in the data view of IBM SPSS and then the temperature data were defined from the data define option. In case of consistent data, at first Expert Modeler was chosen from the analyze option and for each execution of the model some statistical parameters; stationary R^2, R^2, Root Mean Square Error (RMSE) and normalized Bayesian information criterion (BIC), of the model were chosen to plot. When the model was run, it showed both graphical and numerical forecasted values and the forecasted values were saved along with other model statistical parameters. In the second step, the model was run with Exponential Smoothing option which has three criteria; i.e. Holt's Linear Test, Brown Linear Test and Damped Linear Test. Exponential Smoothing with these entire three criteria were executed sequentially. In all cases the model statistics; stationary R^2, R^2, root mean square error (RMSE) and normalized Bayesian information Criterion (BIC) were compared. From the Expert Modeler, Exponential Smoothing with Holt's Linear, Exponential Smoothing with Brown Linear, and Exponential Smoothing with Damped Linear test, the best time series model was chosen based on maximum R^2, minimum RMSE and minimum normalized BIC values. Then forecasted temperatures of that best model were taken and exported to Microsoft excel.

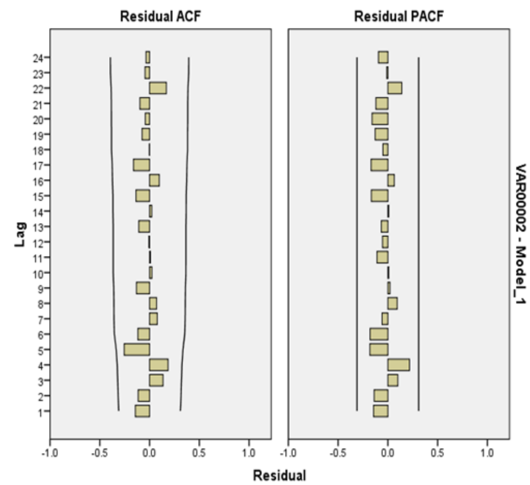

Fig. 3. ACF and PACF after becoming the data stationary

In the ARIMA (p, d, q) model *p* means the number of autoregressive orders in the model. Autoregressive orders specify which previous values from the series are used to predict the current values. For example, an autoregressive order of 2 specifies that the value of the series two time periods in the past be used to predict the current value. In this case a higher value of *p* (29) was preferred almost in all cases. The parameter *d* (1) refers the order of differencing applied to the series before estimating models. Differencing is necessary when trends are present (series with trends are typically non-stationary and ARIMA modeling assumes stationarity) and is used to remove their effect. The order of differencing corresponds to the degree of series trend--first-order differencing accounts for linear trends, second-order differencing accounts for quadratic trends, and so on. The last parameter *q* (0) refers the number of moving average orders in the model. Moving average orders specify how deviations from the series mean for previous values are used to predict the current values. For example, moving-average orders of 1 and 2 specify that deviations from the mean value of the series from each of the last two time periods be considered when predicting the current values of the series.

For the forecasting of inconsistent data ARIMA (29,1,0) model was used in almost all cases. Pure mathematical form of ARIMA model can be written as follows:

$$W_t = \mu + \frac{\theta(B)}{\varphi(B)}\alpha_t$$

Where,

t is the index time

Wa is the response series Y_t or a difference of the response series

μ is the mean term

B is the backshift operator that is; $B\,X_t = X_{t-1}$

$\varphi(B)$ is the autoregressive operator, represented as a polynomial in the back shift operator: $\varphi(B) = 1 - \varphi_1 B \,\ldots\ldots\ldots\, \varphi_p B^p$

$\theta(B)$ is the is the moving-average operator, represented as a polynomial in the back shift operator: $\theta(B) = 1 - \theta_1 B \,\ldots\ldots\ldots\, \theta_p B^p$

α_t is the independent disturbance, also called the random error.

Finally the forecasted monthly mean of daily averages, monthly mean of daily minimum and monthly mean of daily maximum temperatures from all the best models were saved and exported to Microsoft Excel. The graphs of the individual temperature types and individual months were plotted and analyzed afterwards.

2.5 Model Calibration

To test the performance of the model prior to forecasting for historical temperature is known as the model calibration. Calibration provides an impression about the degree of accuracy of the model in forecasting process. This model has been calibrated using the historical temperature. In this study forecasting started from 1975 and ends at 2050. To calibrate the model, this study focused on the observed temperatures of last 10 years and found that model fit values matched with the observed values showing variations not more than 0.6 percent only (Fig. 4). In the beginning of the time period the forecasted values (or model fit values) showed significant differences with the observed values but with being time the model fit values got closer and showed almost same as observed temperature of last 10 years. Thus the forecasted values are assumed authentic and reliable. The graphical representation of the observed and model fit values is shown in Fig. 4.

3. RESULTS AND DISCUSSION

From the historical average temperature, this study revealed that the average temperature declined in winter and spiked in the summer which is an indication of cold winter and hot summer in the future. However, among the all stations Dhaka (Figs. 4-7), Chittagong, Sylhet and Cox's Bazar showed an exceptional case where temperatures were never went below but in both winter and summer the temperature increased significantly which is consistence with reference [30]. In winter, the magnitude of the historical minimum temperature decreased by 0.3℃ to 1.6℃ from 1975 to 2014 where the maximum decreasing rate was observed in January (Figs. 8-11). On the contrary, in summer the extent of the maximum temperature increased by 0.5℃ to 3.0℃ throughout the total time period where the maximum increasing rate was observed in April (Figs. 8-11). The projected temperature shows that the maximum temperature may increase up to $1.50℃ \pm 0.3℃$ from 2015 to 2050 and minimum may vary by $-0.8 \pm 0.2℃$. The summarized results of all stations are shown in the Table 2 (ANNEX).

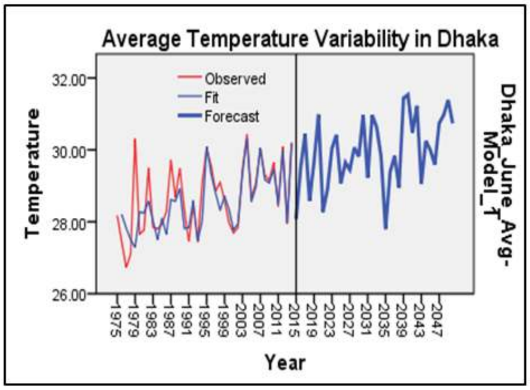

Fig. 4. Comparison of historical and forecasted temperature

Dhaka and Chittagong are considered as the mega cities of Bangladesh. The concentrations of Green House Gases (GHGs) in the atmosphere and humidity have direct influence on the increase in temperature. But in these two mega cities, there may have some other reasons behind the local temperature rise in addition to these two factors. For example, heat emissions from the industries, vehicles and also a very dense population may contribute greatly to the temperature rise. In this sense, Sylhet and Cox's Bazar were supposed to show different trends as they are not like Dhaka and Chittagong. However, this study did not deal with the causes of temperature rise but worked only on the statistical analysis and finally projected up to 2050.

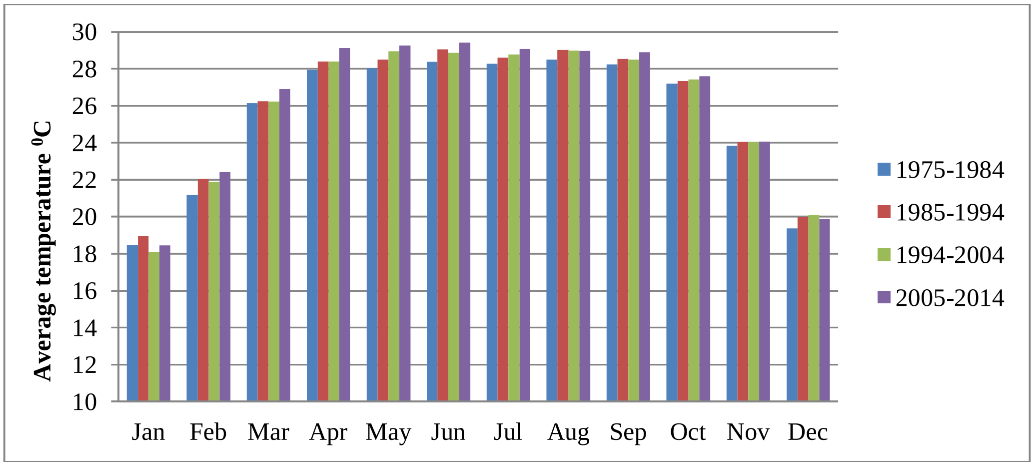

Fig. 5. Decadal average of the monthly average temperature in Dhaka

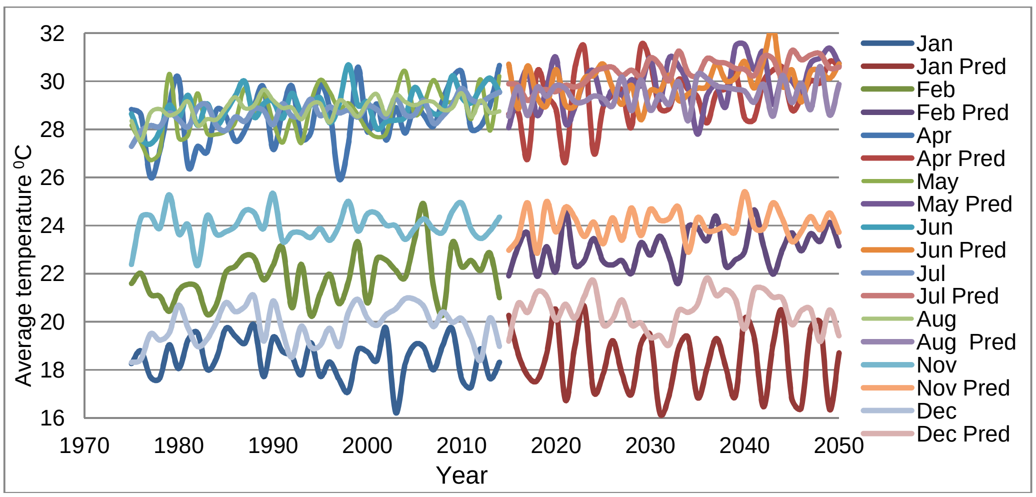

Fig. 6. Average temperature variations in Dhaka

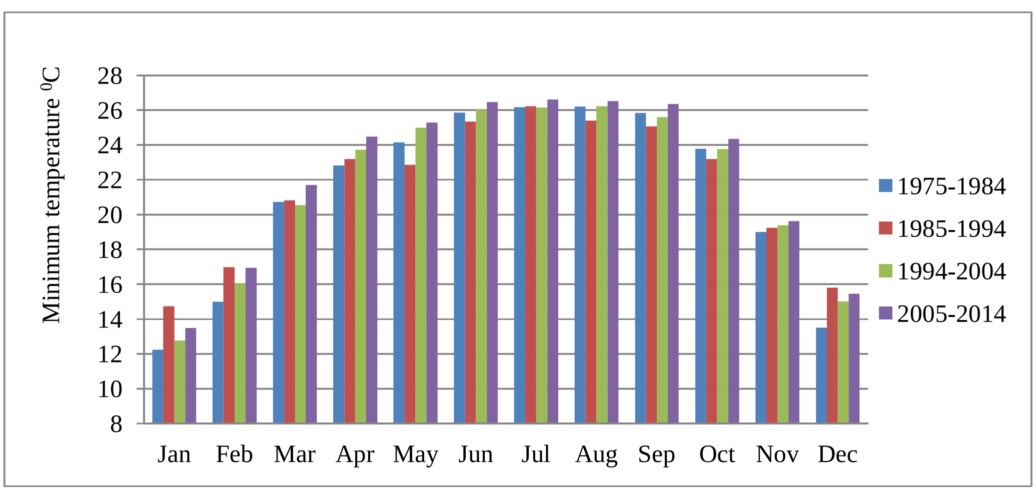

Fig. 7. Decadal averages of the monthly minimum temperature in Dhaka

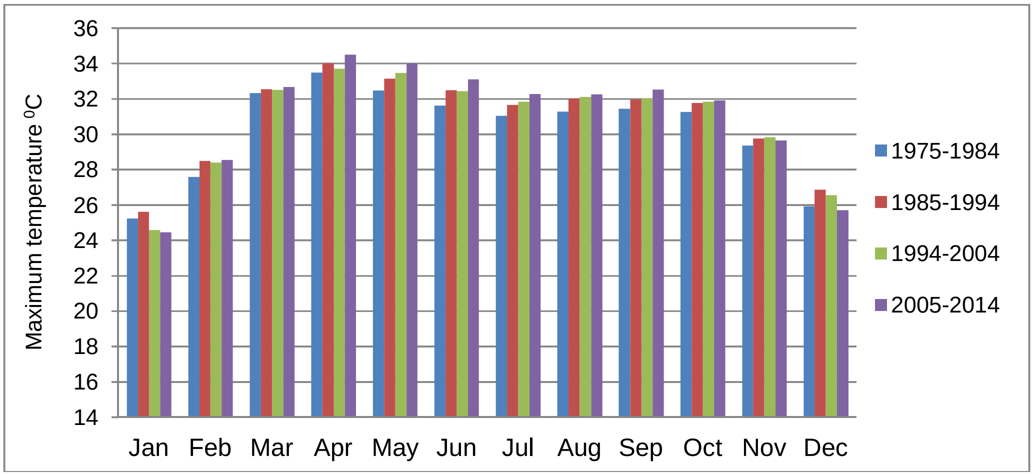

Fig. 8. Decadal averages of the monthly maximum temperature in Dhaka

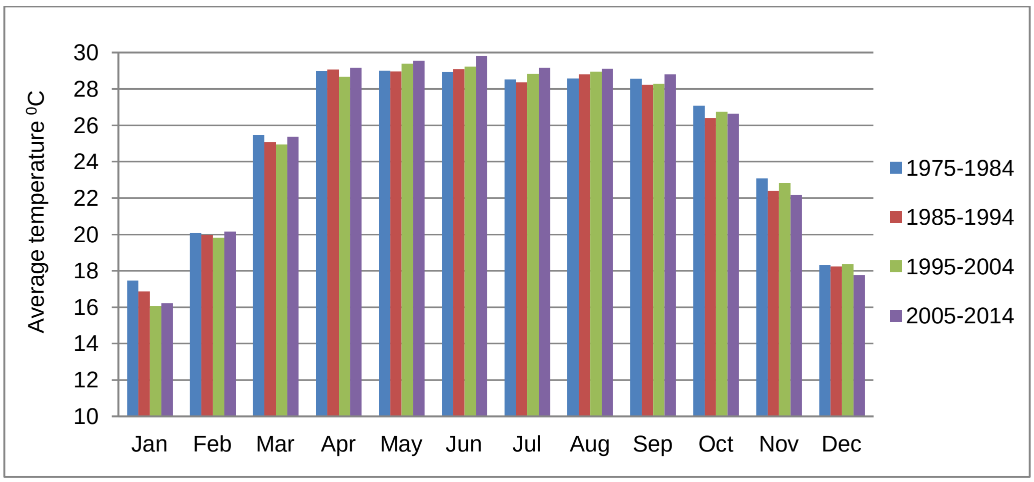

Fig. 9. Decadal average of the monthly mean temperature in Rajshahi

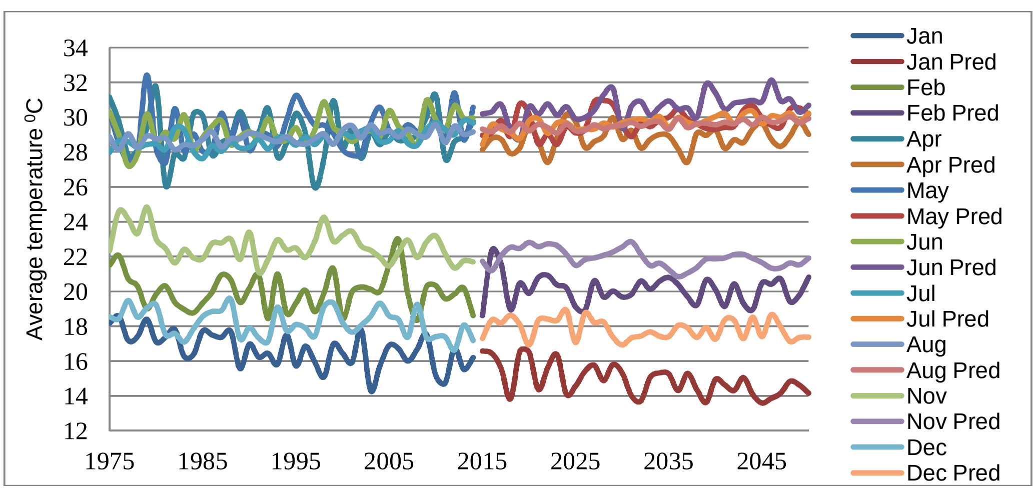

Fig. 10. Average temperature variations in Rajshahi

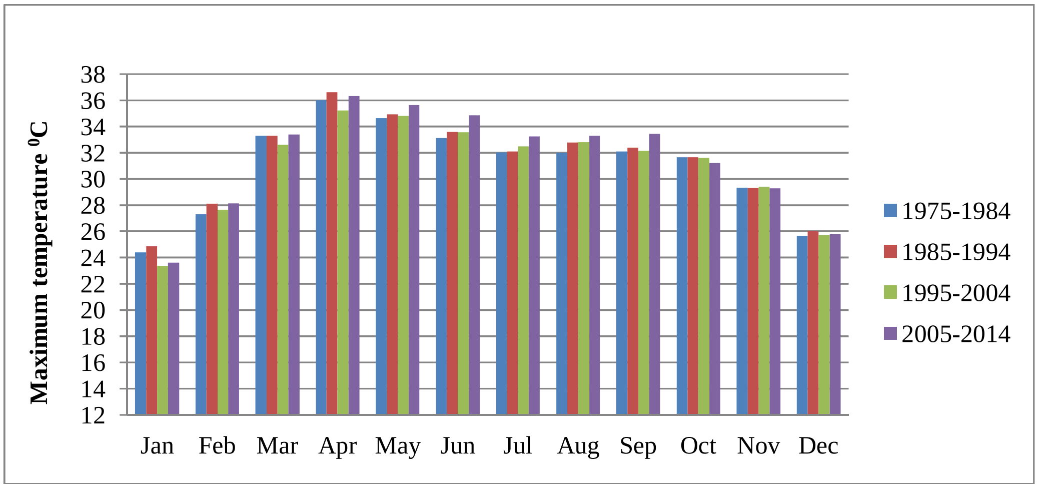

Fig. 11. Decadal averages of the monthly maximum temperature in Rajshahi

This study used the temperature data from 1975 to 2014 and observed yearly variations of the individual months. For example, the variations of the maximum, minimum and average temperatures of the month January throughout the total time period. But from the yearly variations of the individual months, it is really difficult to assess the trends as the magnitude of the temperature fluctuated a lot through the entire time period. For this reason this study mainly focused on the decadal variations which made the things easy to assess the variations of individual months. Based on this observation, this study suggests that the highest increase in the maximum and average temperature was observed in April and maximum temperature increased during summer and also in winter except the month of January which is consistent with the observation of Rahman 2013 and Basak et al. 2013. However, among the thirteen stations Dhaka, Chittagong, Sylhet and Cox's Bazar showed different trends unlike the others.

The trends and variability of the forecasted temperatures were based on their previous historical records as a non-seasonal ARIMA (29,1,0) model was used for the forecasting. Sample standardized residual and their distribution is shown in Fig. 12.

The forecasted temperature in this study showed bit different nature than the other studies. For instance, Rahman & Lateh (2015) found that by 2020 the maximum temperature will rise by $1.0℃$ whereas this study found maximum temperature may lead by $1.50 \pm 0.3℃$ by 2050. This study also found that an average temperature may lead by $1.0 \pm 0.3℃$ by 2050 and the minimum temperature may vary by $-0 \pm 0.2℃$ which is positively consistent with the trend of the reference [25] but not with the numerical figures exactly. However, the forecasted values also depend on model type used and their forecasting process. This study used Box-Jenkin's algorithm using IBM-SPSS which is based on the historical data only. But temperature variations mainly rely on some environmental and climatological factors which are not taken into consideration in this study.

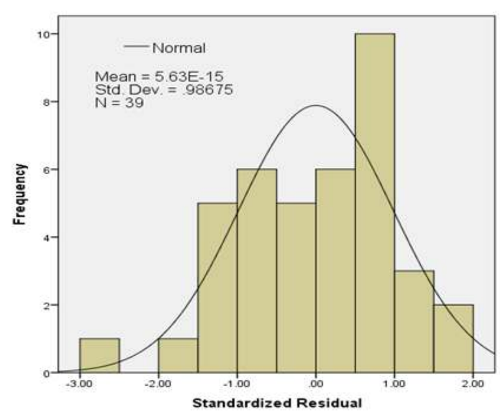

Fig. 12. Sample standardized residuals of ARIMA (29,1,0) and its normal distribution of average temperature (June) in Dhaka

It is worth noting that the forecasting of temperature is kind of prediction which may be or may not turnout exact in the future. But if the existing state contains business as usual then the forecasted results may come true over time.

4. CONCLUSION

Based on the historical and forecasted temperatures, this study concludes that winter may get colder and reverse may happen for the summer where January and April would be the coldest and the hottest months respectively in the future. By the year 2050, the average temperature may rise by $1.0 \pm 0.3℃$ and the maximum temperature may lead by $1.50 \pm 0.3℃$, whereas the minimum temperature may vary by $-0 \pm 0.2℃$.

Overall, Bangladesh is likely to experience a relatively warmer weather in years to come. However, using temperature records of all the available stations and improving forecasting techniques, the predictions can be made far more precisely.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. IPCC, Climate Change 2014 Synthesis Report, Contrib. Work. Groups I, II III to Fifth Assess. Rep. Intergov. Panel Clim. Chang. 2014;1–112.
2. J. Zutt, Warming climate to hit Bangladesh hard with sea level rise , more floods and cyclones, World Bank Report Says. 2013;6–8.
3. Tol RSJ. The economic impact of climate change in the 20th and 21st centuries, Clim. Change. 2013;117(4)795–808.
4. Kreft S. Eckstein D. Kerestan C, Hagen U. Global climate risk index 2015: Who suffers most from Extreme weather events? Weather-related Loss Events in 2013 and 1994 to 2013; 2015.
5. Bisset R, Cieslik N. New report examines risks of 4 degree hotter world by end of century. The World Bank Group; 2012.
6. Biswas M. Climate Change & its Impacts on Bangladesh Introduction. 2013;86–95.
7. Weather Online, climate of the world: Bangladesh, Weather Online; 2016.
8. Aziz A, Hossain I, Rahman NF. Effects of rainfall and maximum temperature on aman rice production of Bangladesh : A Case Study For Last Decade, Dep. Environ. Dhaka. 2014;3(2)131–137.
9. Basak JK. Changing rainfall pattern effects on water requirement of Aman T. Cultivation in Bangladesh. 2011;11(June)1–8.
10. Hossain A, Da Silva JAT. Wheat production in Bangladesh: Its future in the light of global warming, AoB PLANTS. 2013;(5).
11. Mahmood R. Impacts of air temperature variations on the boro rice phenology in Bangladesh: Implications for irrigation requirements, Agric. For. Meteorol. 1997;84(3–4):233–247.
12. GoB, Climate change and agriculture in Bangladesh: Information brief, Minist. Environ. for. Gov. People's Repub. Bangladesh, Financ. Support DFID DANIDA; 2012.
13. Shahid S. Probable impacts of climate change on public health in Bangladesh, Asia Pac J Public Heal. 2010;22(3): 310–319.
14. Khan AE, Xun WW, Ahsan H, Vineis P. Climate change, sea-level rise, & health impacts in Bangladesh, Environ. Sci. Policy Sustain. Dev. 2011;53(5):18–33.
15. Ford LB. Climate change and health in Bangladesh. 2009;12(1):78–84.
16. Ruhul Amin M, Zhang J, Yang M. Effects of climate change on the yield and cropping area of major food crops: A case of Bangladesh, Sustain. 2015;7(1): 898–915.
17. Sarker MAR, Alam K, Gow J. A comparison of the effects of climate change on Aus, Aman and Boro rice yields in Bangladesh: Evidence from panel data, in 41st Australian Conference of Economists (ACE 2012). 2012;1–28.
18. Karim MR, Ishikawa M, Ikeda M, Islam T, Climate change model predicts 33% rice yield decrease in 2100 in Bangladesh. Agron. Sustain. Dev. 2012;32(4):821–830.
19. Hashizume M, Wagatsuma Y, Hayashi T, Saha SK, Streatfield K, Yunus M. The effect of temperature on mortality in rural Bangladesh-a population-based time-series study. Int. J. Epidemiol. 2009;38(6):1689–1697.
20. Cell CC. Climate change and health impacts in Bangladesh. Dep. Environ. Dhaka. 2009;20(June):45–56.
21. Rahman AJH. Sohul AM. Regional variation of temperature and rainfall in Bangladesh: Estimation of trend. J. Appl. Comput. Math. 2015;4(5):4–6.

22. Rahman MZ. Change in temperature over Bangladesh associated with degrees of Global Warming. 2013;2(2):62–75.
23. Rahman MR, Lateh H. Climate change in Bangladesh: A spatio-temporal analysis and simulation of recent temperature and rainfall data using GIS and time series analysis model. Theor. Appl. Climatol. 2015;1–15.
24. Mohiuddin H, Musfiqur Rahman Bhuiya M, Mahmud Al Mamun M. An analysis of the temperature change of Dhaka City. 2014;46–48.
25. Basak JK, Titumir RAM, Dey NC. Climate change in Bangladesh: A historical analysis of temperature and rainfall data. J. Environ. 2013;2(2):41–46.
26. M. Alam. Process development for hydrological region- wide integrated water resources management model in Bangladesh. Asian J. Appl. Sci. Eng. 2015;4(2):137–146.
27. Guha B, Bandyopadhyay G. Gold price forecasting using ARIMA model. J. Adv. Sci. 2016;4(2):117–121.
28. Ranjbar M, Khaledian M. Using Arima time series model in forecasting the trend of changes in qualitative parameters of Sefidrud River. Int. Res. J. Appl. Basic Sci. 2014;8(3):346–351.
29. Şchiopu D, Petre EG, Negoińă C, Weather forecast using SPSS Statistical Methods. 2009;LXI(1):97–100.
30. Rahman AJH. Sohul AM. Regional variation of temperature and rainfall in Bangladesh: Estimation of trend. J. Appl. Comput. Math. 2015;4(5): 652–657.

ANNEX

Table 2. Summary of the historical temperature of individual stations

Stations	Temperature		
	Average	**Maximum**	**Minimum**
Dhaka	Increased in all months	Increased in all months except January.	Increased in all months.
Chittagong	Increased in all month but almost remained same in January	In all months increased in first three decades but decreased in the last decade.	Increased in all months.
Khulna	Remained almost the same in all months except December where increased a little in the last decades	Increased in all months except January where a bit decreased.	Little increased in winter but almost remained the same in summer.
Rajshahi	Significant decreased in winter and little increase in summer	Decreased in January and little increase in summer and almost remained same in October, November and December	Little increase in summer except May. In winter only in January remained same but increased in December
Rangpur	Increased in all months except January where it decreased but remained almost the same in December.	Increased in all months except January where decreased in last three months. But in the last decade in the month of December otherwise increased in the first three decades.	Increased in all months except January, May and June where it remained the same only in December it decreased.
Bogra	Increased in all months except January and December.	Increased in all months except January and December.	Increased in all months except January and December.
Mymensing	Decreased in November, December, January and February. In other months it remained almost the same with little fluctuations.	Increased in all months except January, March and April.	Increased in all months throughout the total time period.
Jessore	A little decrease in December, January and March otherwise increased but not significantly.	Increased in all months except January.	Increased in all months except December, January and February.
Sylhet	Increased in all months except January where little fluctuations observed.	Increased in all months throughout the total time period.	Increased in all months throughout the total time period.
Cox's Bazar	Increased in all months throughout the total time period	Increased in all months throughout the total time period.	Increased in all months throughout the total time period
Khepupara	Decreased in December, January and February. On the contrary, it remained the same in the other months.	Increased in all months throughout the total time period.	Decreased in November, December, January, February and March whereas in the other months a little

Stations	Temperature		
	Average	**Maximum**	**Minimum**
			increase was observed.
Barisal	Decreased only in January but increased in April, May and June whereas in others months it did not show any significant variation.	Increased in all months except January where decreased very little.	Increased in all months throughout the total period of time.
Comilla	Decreased only in January but in the other months it remained almost the same.	Decreased only in January but increased in the other months except December where it fluctuated.	Increased in all months except January where decreased very little.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/18953