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Climate Change

Microclimatic study using temperature data of Jahangirnagar University of Bangladesh

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Microclimate is characterize the climate of a localized area may vary on the order of one square meter to as long as the order of 100 square kilometers even. In this study, detail descriptions of the microclimatic conditions and the trends of temperature of Jahangirnagar University have been assessed. The secondary data for the last 10 years have been collected from the Weather Station of the Department of Geography and Environment of this university. The microclimatic data for both building interior and open space were selected for the study. Regression analysis was performed by Excel and other statistical software to find out the trend line analysis for climatic variability. Data analysis indicates that there are strong differentiations between the temperature of different periods and places of the study. Overall temperature was distinctly low during midnight to morning time compared to other parts of the day in the study area. Again at morning, the temperature was found lower in the building interior than open space in winter and found reverse in summer or pre-monsoon period. In summer, the temperature was found higher in building interior than open space. During usual monsoon rainfall was occurring in this area. Most of the cases the temperature was normal in the sense of ideal microclimatic conditions,but remarkable deviations were also marked during data analysis which has been defined and analyzed by the existing climatic phenomena.

INTRODUCTION

Climate is the average patterns of weather variables in a given region over long period of time (Shepherd et al., 2015, Muhammad Rezaul Rakib & Md. Nurul Islam, 2017). Microclimate is the distinctive climate of a small-scale area (Jebson, 2007). The weather variables in a microclimate may be different to the conditions prevailing over the area (Adams, 2007). Microclimates can be found in most places and characterize a localized area (Peng and Jim, 2013). The scale of geography may vary on the order of one square meter or as large as the order of 100 square kilometers. The chief factors comprising microclimate are surface temperature, relative humidity, wind speed, solar insolation and precipitation (Friesner and Ek, 1944; Caborn, 1973; Haworth and McPherson, 1995; Clinton, 2003). These factors derive from the confluence of larger scale meteorology with localized topographic elements (Barry, 1992). This may have a unique pattern of weather or weather effects that differ from the local climate (Chen *et al.*, 1999; Morss *et al.*, 2011; Stewart and Oke, 2012). The microclimate can vary on the south side of a building from the one on the north, so that different plants may thrive (Yates, Norton and Hobbs, 2000; Raghu, Drew and Clarke, 2004; Malys, Musy and Inard, 2015; Taleghani *et al.*, 2015). The hilly coastal area are the home of many different microclimates (Stefanucci *et al.*, 2005; Suggitt *et al.*, 2011; Van Rijn, 2011; Lawson *et al.*, 2014; Shahrestani *et al.*, 2015).

A microclimatic area can offer an opportunity as a small growing region for crops. This can be used to take the advantage of gardeners who carefully choose and position their plants, zoning, and a sheltered position can reduce the severity of winter and also for roof gardening tall buildings create their own microclimate, both by overshadowing large areas and by channeling strong winds to ground level (Adams and Bischof, 1994; Ong *et al.*, 2000; Baille, Kittas and Katsoulas, 2001; Tanny, 2013; Wang *et al.*, 2015; Mohan Singh and Suman Jangra, 2018). Wind effects around a tall buildings can be assessed as part a of microclimate study (de La Flor and Dominguez, 2004; Gulyás, Unger and Matzarakis, 2006). Microclimates can also refer to purpose-made environments. Even the type of soil affect microclimates may be quite small protected courtyard next to a building (Van Rijn, 2011). Vegetation has a great role in shaping microclimate of an area. Because they also shade the landscape, plants create microclimates. Analysis of climatology at micro scale is the most useful tool for the representation of the climate of that region (Giorgi, Francisco and Pal, 2003; Patz *et al.*, 2005). In Bangladesh, such study has been done only in a few number to analyze the pattern and trend of rainfall, temperature, solar radiation, relative humidity, heat budget and energy balance on different ecosystem and meteorological unit. Jahangirnagar University which is under Dhaka district has a tropical wet and dry climate. The climate of this region is generally marked with monsoon, high temperature, considerable humidity and moderate rainfall. But past records have prevailed that no study has done to analyze the relationship between climatic parameters and climate change trends of the study area with

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microclimatic analysis. Under these contexts, this study has conducted to relate climatic variables and climate change for the study area.

Aims and objectives

The aim of this study is to analysis the microclimatic conditions using temperature data of Jahangirnagar University campus of Bangladesh. The broad objectives of the study are:

a) To find out the temperature at different microclimatic areas of the campus; and

b) To analysis the temperature changes in the study area during 2005 to 2014.

METHODOLOGY

Study Area

To study the microclimatic weather conditions, Jahangirnagar University has been selected as the study area. Jahangirnagar University is located at Savar Upazilla in Dhaka district (Fig. 01). The total area of the university is 697.56 acre. The average temperature of this regions is (Dhaka weather Station based) 25 °C (77 °F) and monthly mean varying between 18 °C (64 °F) in January and 29 °C (84 °F) in August. Nearly 80% of the annual average rainfall of 1,854 millimeters (73.0 in) occurs during the monsoon season which lasts from May until the end of September (BMD, 2016).

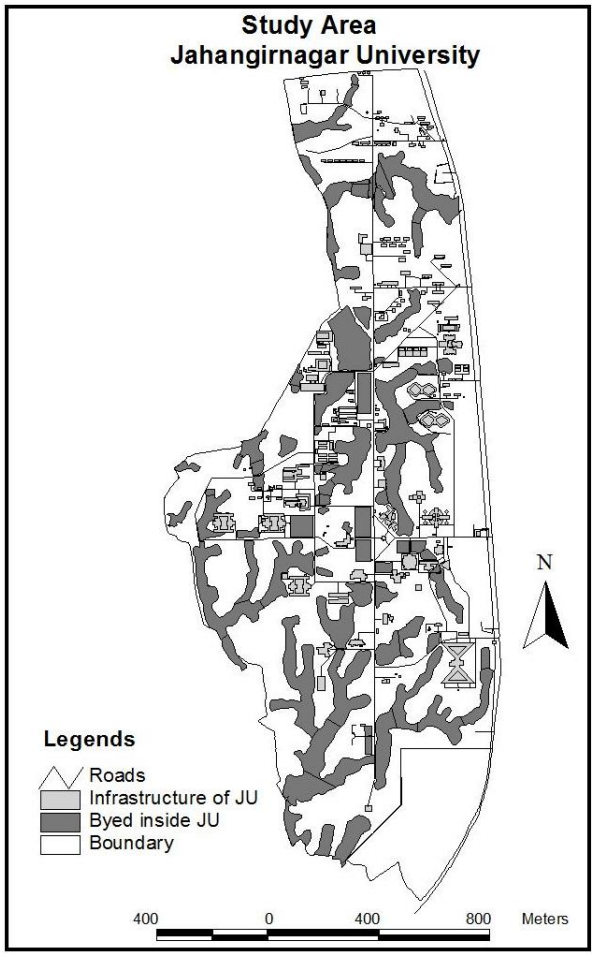

Figure 1 Study Area
Source: Jahangirnagar University; Compiled by Authors, 2018.

Data and Methods

Both primary and secondary data has been used to microclimatic study. Mainly temperature parameter is taken as climatic parameters, which data are collected from the weather station of the department of Geography and Environment at Jahangirnagar University of Bangladesh. In addition to, filed survey and field observation were conducted in the study area. Moreover, extensive literature review and others secondary documents which are related with microclimate also considered. After collecting the temperature data, date were organized and input by statistical software. Finally, correlation and regression analysis were undertaken based on time series temperature data to find out the trend line and microclimatic condition of the study area.

RESULTS AND DISCUSSION

In this section, the detailed analysis of the data and the results of the study are given. Bangladesh has a tropical rainstorm sort atmosphere, with a hot and blustery summer and a dry winter. January is the coolest month with temperatures averaging almost 26^0 C (78^0 F), and April is the hottest with temperatures from 33^0 to 36^0 C (91^0 to 96^0 F). The atmosphere is one of the wettest on the planet. Most places get more than 1,525 mm of rainfall a year, and zones close to the slopes get 5,080 mm. Most rains happen amid the storm (June-September) and little in winter (November-February) (BMD, 2016).

Microclimatic Temperature Status

From the table 1, it reveals that the overall trend of maximum temperature had decreasing trends, but the minimum temperature had increasing trend and the year of 2013 had the lowest minimum temperature at the Jahangirnagar University. The mean temperature of January is decreasing. The maximum temperature of the month February from the year of 2005 and 2006 had increasing trends and the overall trend of maximum, minimum and mean temperature had decreasing trends. The temperature variation between February and March are on an average 2^0 C except the year of 2007. The other years had a temperature above 30^0 C. Again the month of April had 2 degree higher temperature than the month of March and temperature had increasing trends. The month of May had an increasing trend of temperature. The temperature had an anomaly and had a variation among different years. The trend of increasing the maximum temperature was 0.11^0 C per year, and it is 0.13^0 C per year for minimum temperature and 0.14^0C per year for mean temperature.

Besides, the temperature conditions for the month of June of the last 10 years indicate that temperature had an increasing trend. The trend for maximum temperature was +.077 and +0.07 for minimum temperature, and the mean temperature had +0.086 during the period of 2005 to 2014. Though the temperature of July had a uniform pattern, it also had an increasing trend of temperature. The trends of increasing the maximum temperature were 0.147 ^{0} C per year, and it is 0.080^0C per year for minimum temperature and 0.114^0C per year for mean temperature. The analysis for the temperature conditions for the month August for the last 10 years indicates that temperature had an increasing trend.

In addition to, the trend for maximum temperature was $+.53^0$C per year and $+0.07^0$C per year for minimum temperature and the mean temperature had $+0.086^0$C per year during the period of 2005 to 2014. September had an increasing trend of maximum temperature.

Moreover, the analysis for the temperature conditions for the month September for last 10 years indicates that normal temperature of the month September are lower than August. The trend for maximum temperature was $+0.314^0$ C per year and $+0.039^0$ C per year for

Table 1 Temperature status of Jahangirnagar University

Year	Month	Max. Temp.	Min. Temp.	Mean	Year	Month	Max. Temp.	Min. Temp.	Mean
2005	Jan	23.25	14.47	18.86	2010	Jan	21.79	13.89	18.09
	Feb	27.22	20.56	23.89		Feb	27.57	17.56	22.26
	Mar	30.22	23.51	26.87		Mar	32.97	25.34	28.99
	Apr	32.64	26.26	29.45		Apr	33.95	28.42	31.09
	May	31.97	26.18	29.08		May	33.31	28.02	30.58
	Jun	32.82	28.11	30.46		Jun	32.13	27.65	29.92
	Jul	30.76	27.24	29		Jul	32.61	28.12	30.19
	Aug	31	27.23	29.11		Aug	32.72	27.82	30.23
	Sep	32.01	27.09	29.55		Sep	31.8	27.25	29.41
	Oct	29.92	24.62	27.27		Oct	32.05	26.2	30.99
	Nov	27.89	21.08	24.49		Nov	28.48	22.01	25.28
	Dec	26.52	16.49	21.51		Dec	24.62	15.95	20.43
2006	Jan	23.17	13.86	18.52	2011	Jan	22.38	13.78	18.08
	Feb	29.71	21.83	25.77		Feb	27.19	18.2	22.69
	Mar	30.86	22.18	26.52		Mar	30.88	23.26	27.07
	Apr	33.01	25.95	29.48		Apr	31.25	23.56	27.41
	May	30.88	25	27.94		May	32.2	25.44	28.82
	Jun	32.29	27.64	29.97		Jun	31.14	27.17	29.16
	Jul	31.99	28.4	30.2		Jul	31.38	27.59	29.49
	Aug	31.58	27.66	29.62		Aug	30.48	26.95	28.72
	Sep	31.55	26.98	29.27		Sep	31.8	27.3	29.55
	Oct	32.11	25.93	29.02		Oct	32.37	25.78	29.07
	Nov	28.44	21.51	24.98		Nov	28.02	20.26	24.14
	Dec	24.45	16.51	20.48		Dec	24.05	16.35	20.2
2007	Jan	22.55	13.98	18.26	2012	Jan	22.64	15.79	19.21
	Feb	25	18.7	21.9		Feb	27.17	17.72	22.44
	Mar	29.8	20.9	25.4		Mar	32.09	24.44	28.27
	Apr	32.2	25.2	28.7		Apr	32.3	25.76	29.03
	May	33.7	27.5	30.6		May	33.79	27.61	30.7
	Jun	31.4	27.1	29		Jun	33.32	28.39	30.86
	Jul	30.5	27	28.75		Jul	32.56	27.28	29.92
	Aug	31.4	27.5	29.4		Aug	42.35	27.63	34.99
	Sep	31.3	27.4	28.7		Sep	32.85	27.78	34.99
	Oct	31.3	27.4	28.7		Oct	31.76	25.37	28.56
	Nov	28.8	20.8	24.2		Nov	27.68	19.65	23.67
	Dec	23.9	14.5	19.2		Dec	22.58	15.19	18.89
2008	Jan	21.9	14.3	18.1	2013	Jan	22.05	12.63	17.34
	Feb	25.9	17.8	21.85		Feb	27.96	18.87	23.41
	Mar	30.1	23.7	26.9		Mar	32.55	24.08	28.32
	Apr	33.07	26.15	29.55		Apr	34.01	27.26	30.63
	May	33.24	26.95	29.17		May	30.54	26.2	28.37
	Jun	31.69	27.13	29.18		Jun	33.07	28.41	30.74

Year	Month	Max. Temp.	Min. Temp.	Mean	Year	Month	Max. Temp.	Min. Temp.	Mean
	Jul	30.59	26.45	28.46		Jul	31.68	28.19	29.93
	Aug	31.03	26.18	28.55		Aug	30.94	28.52	29.73
	Sep	31.94	27.42	28.84		Sep	32.14	28.72	30.43
	Oct	30.85	24.92	27.89		Oct	31.64	27.12	29.38
	Nov	28.29	19.59	23.94		Nov	27.48	20.68	24.08
	Dec	24.63	17.77	21.2		Dec	23.99	17.63	20.81
2009	Jan	24.29	15.77	19.92	2014	Jan	22.68	15.12	18.9
	Feb	27.73	18.84	23.55		Feb	25.48	18.33	21.9
	Mar	31.51	22.68	26.56		Mar	31	23.32	27.16
	Apr	33.83	27.46	30.66		Apr	35.25	26.9	31.08
	May	32.38	26.31	29.05		May	34.5	27.9	31.2
	Jun	33.25	28.06	30.62		Jun	32.87	28.11	30.49
	Jul	31.87	27.79	29.73		Jul	32.22	28.31	30.26
	Aug	32.02	27.65	29.76		Aug	31.56	27.67	30.26
	Sep	32.25	27.68	29.83		Sep	31.99	27.69	29.84
	Oct	30.83	25.38	28.17		Oct	31.69	25.99	28.84
	Nov	28.54	21.92	25.17		Nov	29.5	26.67	28.08
	Dec	24.52	16.22	20.5		Dec	22.9	16.08	19.49

Source: *Weather Station, JU*

minimum temperature and the me4an temperature had +0.109^{0}C per year during the period of 2005 to 2014. The month of October is the transition month between monsoon and winter and had an increasing trend of temperature.

Furthermore, the ending of the month May and first week of June is a month of pre-monsoon in Bangladesh. The open space-building interior temperature of the study indicates that the morning temperature was 27.80 ^{0}C in building interior and the open space temperature was 27.47^0 C.

The mid-day or noon time temperature was 32.20^{0}C in open space zone and 31.40 ^{0}C in building interior zone. The evening time temperature was 30.17^{0}C in open space and the building interior temperature was 30.40^{0}C and the midnight temperature was 28.20 in building interior zone and 28.10^{0}C in building interior zone. So it reveals that in this month there were variations in temperature in different period of the day. The temperature was found very hot in April and the January month was very cold. The mean temperature of different period of the day indicates heterogeneity in temperature.

Monthly Temperature Condition

June is a month of pre-monsoon in Bangladesh. The open space-building interior temperature of the study indicates that in the morning of the May 15, 2016, the temperature was 27.13^{0}C in building interior and the open space temperature was 26.23^0 C. The midday or noon time temperature was 31.27^{0}C in open space zone and 31.43^{0}C in building interior zone. The evening time temperature was 28.30 in open space and the building interior temperature was 28.30^{0}C and the midnight temperature was 28.10^{0}C in building interior zone and 28.13^{0}C in building interior zone (Fig. 02 & 03).

May is the month of pre-monsoon and transition month of monsoon in Bangladesh. The open space-building interior temperature of the study indicates that in the morning of the May 2, 2016, the temperature was 29.10^{0}C in building interior and the open space temperature was 28.70^0 C. The midday or noon time temperature was 33.83^{0}C in open space zone and 33.60^{0}C in building interior zone. The evening time temperature was 30.17^{0}C in open space and the building interior temperature was 30.30^{0}C and the mid night temperature was 29.40^{0}C in building interior zone and 29.20^{0}C in building interior zone (Fig. 04).

In April, the temperature was found higher than other months. The open space-building interior temperature of the study indicates that in the morning of the April 3, 2016, the temperature was 31.83^{0}C in building interior and the open space temperature was 31.40^0 C. The midday or noon time temperature was 33.80^{0}C in open space zone and 33.90^{0}C in building interior zone. The evening time temperature was 31.23^{0}C in open space and the building interior temperature was 31.40 and the mid night temperature was 30.63^{0}C in building interior zone and 30.40^{0}C in building interior zone (Fig. 05).

March is hot and warm month of Bangladesh. The temperature is increasing than previous month. The open space-building interior temperature of the study indicates that in the morning of the March 3, 2016, the temperature was 20.17^{0}C in building interior and the open space temperature was 20.20^{0}C. The midday or noon time temperature was 26.23^{0}C in open space zone and 26.17^{0}C in building interior zone. The evening time temperature was 23.17^{0}C in open space and the building interior temperature was 22.90^{0}C and the midnight temperature was 21.70^{0}C in building interior zone and 21.13^{0}C in building interior zone (Fig. 06).

February is the last month of winter in Bangladesh. The open space-building interior temperature of the study indicates that in the morning of the February 2, 2016, the temperature was 20.13^{0}C in building interior and the open space temperature was 17.60^0 C. The midday or noon time temperature was 23.33^{0}C in open space zone and 24.37^{0}C in

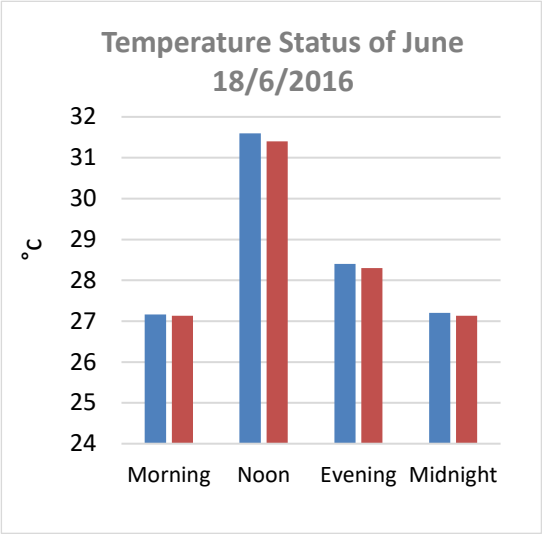

Figure 2 Temperature status of June 18/6/2016 (left)

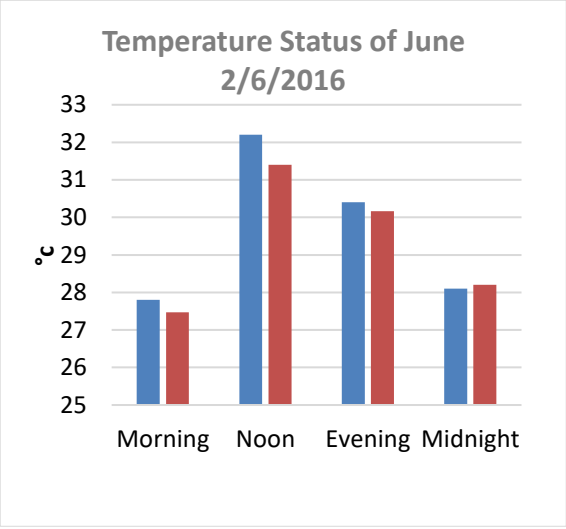

Figure 3 Temperature status of June 2/6/2016 (right)

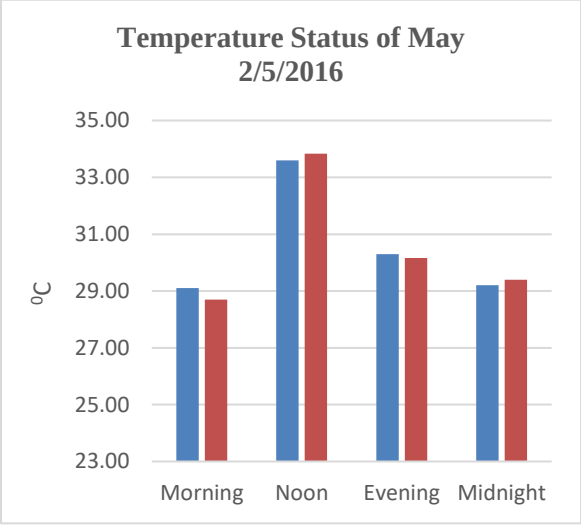

Figure 4 Temperature status of May first week (2/5/2016)

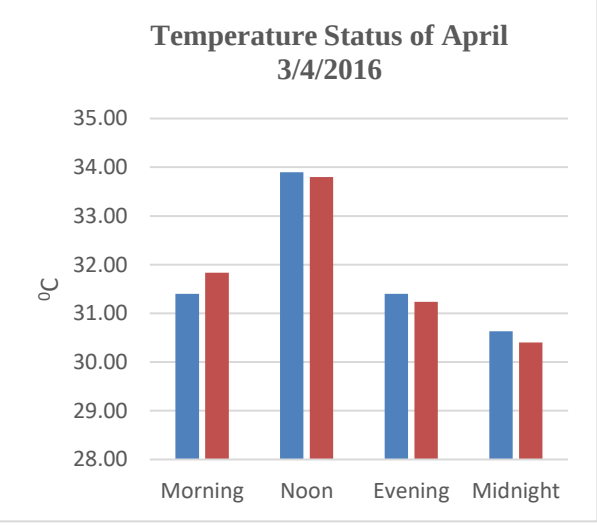

Figure 5 Temperature status of April first week (3/4/2016)

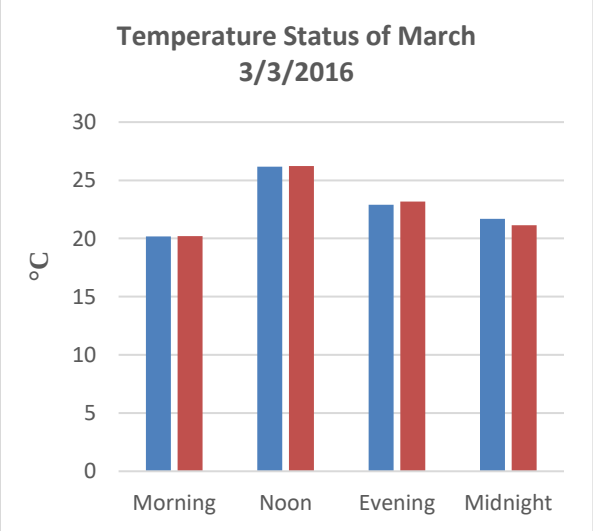

Figure 6 Temperature status of March first week (3/3/2016)

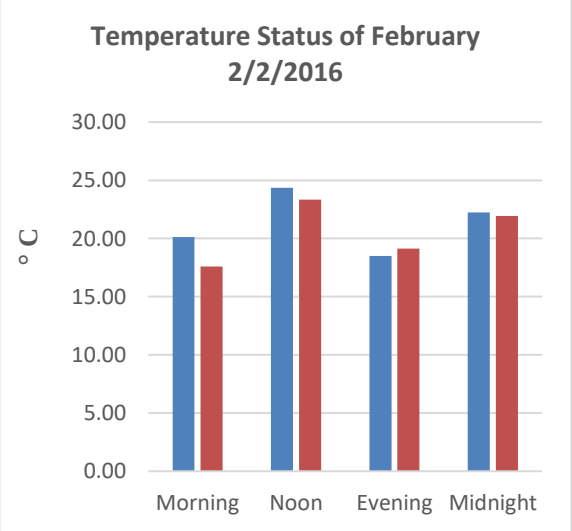

Figure 7 Temperature status of February (2/2/2016)

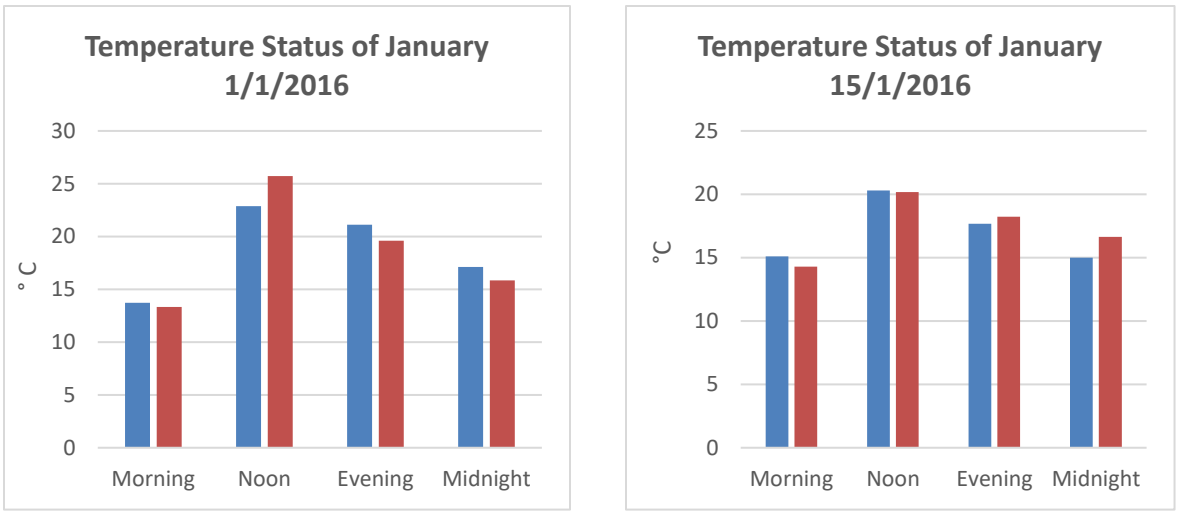

Figure 8 Temperature status of January (1/1/2016 (left) and 15/1/2016 (right))

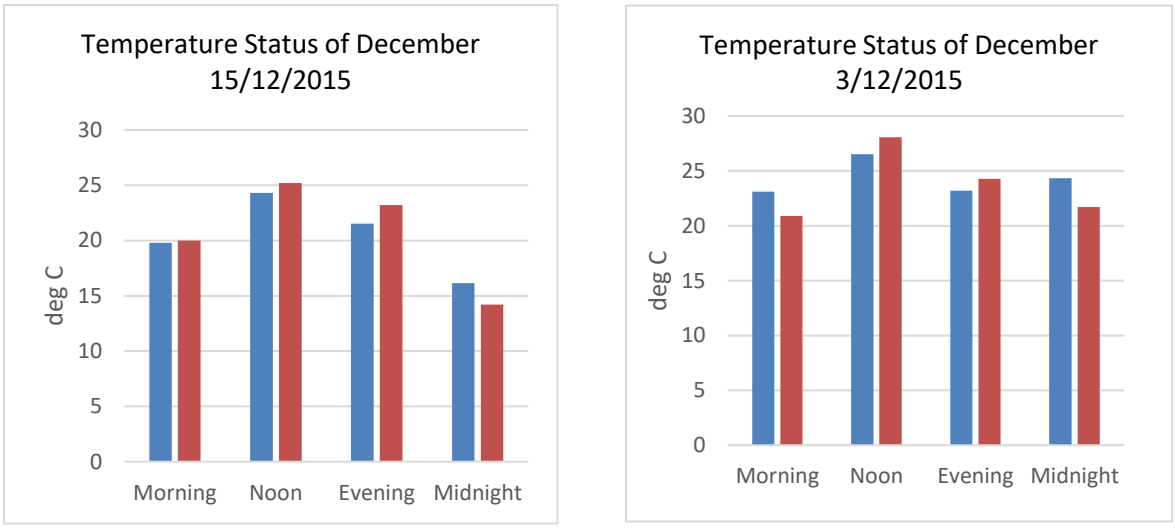

Figure 9 Temperature status of December (15/12/2015(left) and 3/12/2015(right))

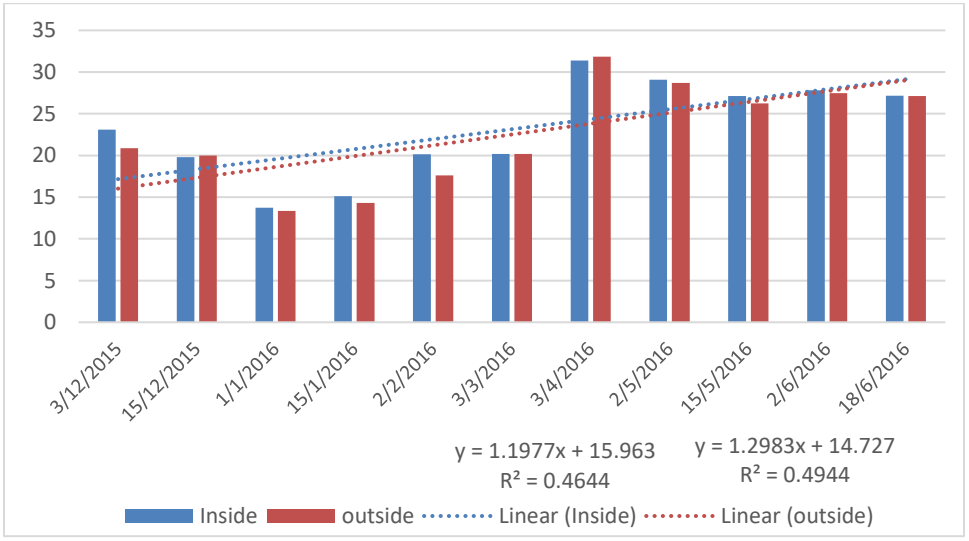

Figure 10 Trends in Temperature change in microclimatic area

building interior zone. The evening time temperature was 19.13^{0}C in open space and the building interior temperature was 18.50^{0}C and the mid night temperature was 22.23^{0}C in building interior zone and 21.93^{0}C in building interior zone (Fig. 07).

Differentiations have been found between the temperature of mid-January with first January and First February temperature. The open space-building interior temperature of the study indicates that in the morning of the January 15, 2016, the temperature was 15.10^{0}C in building interior and the open space temperature was 14.30^0 C. The midday or noon time temperature was 20.17^{0}C in open space zone and 20.30^{0}C in building interior zone. The evening time temperature was 18.23^{0}C in open space and the building interior temperature was 17.67^{0}C and the mid night temperature was 15.00^{0}C in building interior zone and 16.63^{0}C in building interior zone (Fig. 08).

The open space-building interior temperature of the study indicates that in the morning of the January 1, 2016, the temperature was 13.73^{0}C in building interior and the open space temperature was 13.33^0 C. The midday or noon time temperature was 25.73^{0}C in open space zone and 22.87^{0}C in building interior zone. The evening time temperature was 19.60^{0}C in open space and the building interior temperature was 21.13^{0}C and the midnight temperature was 17.13^{0}C in building interior zone and 15.83^{0}C in building interior zone (Fig. 09). So it can be said that the temperature conditions were perfectly distributed as stated in the microclimatic area. Analysis indicates that morning had lowest temperature and noon had highest temperature.

In the ending of December and staring of January period had high fog and thus there were less sunlight penetrate on earth surface in the country. All periods except noon time were found less temperature in outside area of the study. In Bangladesh, there are six seasons. Winter is one of them. It is the coldest of all. Generally, it begins it in the middle of November and lasts till middle of February. During winter a cold wind blows from the north. It is a season of mist. It begins to fall at night and disappears when the sun rises in the morning. The days are shorter than the nights in winter. The sun rises late. Sometimes it is not distinctly visible through fog. Dew drops on the grass and leaves of trees during the night glitter like pearls as the sun rays fall on them. Trees become bare of leaves. Nature looks dead and gloomy. The open space-building interior temperature of the study indicates that in the morning of the December 3, 2015, the temperature was 23.11^{0}C in building interior and the open space temperature was 20.89^0 C. The midday or noon time temperature was 28.06^{0}C in open space zone and 26.52^{0}C in building interior zone. The evening time temperature was 24.28^{0}C in open space and the building interior temperature was 23.2^{0}C and the midnight temperature was 24.3^{0}C in building interior zone and 21.7^{0}C in building interior zone (Fig. 10). So it can be said that the temperature conditions were perfectly distributed as stated in the microclimatic area. Analysis indicates that morning had lowest temperature and noon had highest temperature. In the mid-December, the morning temperature was 20^{0}C in building interior, and the open space temperature was 19.8^{0}C. The midday or noon time temperature was 25.2^{0}C in open space zone and 24.2^{0}C in building interior zone. The evening time temperature was 23.2^{0}C in open space and the building interior temperature was 21.53^{0}C and the mid night temperature was 14.20^{0}C in building interior zone and 16.13^{0}C in building interior zone. In December, there had been dense fog, and thus there were less sunlight could penetrate on earth's surface in the country. All periods except noon and evening time were found to have less temperature in open space area of the study.

CONCLUSION

From the above results and discussions, it is found that the overall trend of maximum temperature had decreasing trends, but the minimum temperature had increasing trends and the year of 2013 had the lowest minimum temperature. The mean temperature of January is decreasing. The maximum temperature of the month February from the year of 2005 and 2006 had increasing trends and the month of 2007 and 2008 were same and The overall trend of maximum, minimum and mean temperature had decreasing trends. The temperature variation between February and March are on an average 20^{0}C. Except the year of 2007, the other months had a temperature above 30^{0}C. Again the April month had 2 degree higher temperature than the month of March. The temperature had increasing trends. The May had increasing trends of temperature. The temperature had an anomaly and had a variation among different year. The trend of increasing the maximum temperature was 0.110^{0}C per year, and it is 0.130^{0}C per year for minimum temperature and 0.14^{0}C per year for mean temperature.

There had been strong differentiations between the temperature of different periods and space of the study. Temperature was mainly low in midnight to morning than other periods. Morning temperature was found lower in building interior than open space in winter and found different than this in summer or pre monsoon period. The temperature was found higher in building interior than open space as rain falling was found occurring there in data collection. Most of the cases the temperature was normal in sense of ideal microclimatic conditions but found something different and those were defined by the exiting climatic phenomena. Finally, this analysis was ended up leaving some major questions which author can ask for further research in the field.

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