ANALYSIS OF THE TRENDS IN TEMPERATURE AND PRECIPITATION VARIABLES FOR SYLHET CITY OF BANGLADESH USING RCLIMDEX TOOLKIT

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ABSTRACT

A trend analysis, a process by which information is gathered and analyzed to identify meaningful patterns or trends, is used not only to predict future events, but also to understand events of the past. Sylhet is lo-cated at 24.8917°N 91.8833°E, in the north eastern region of Bangladesh within the Sylhet Division in Bangladesh. The climate of Sylhet is humid subtropical with a predominantly hot and humid summer and a relatively cool winter. The city is within the monsoon climatic zone, with annual average highest temperatures of 23 °C (August-October) and average lowest temperature of 7 °C (January). Nearly 80% of the annual average rainfall of 3,334 mm occurs between May and September. This study covers the trend analysis of temperature and rainfall of Sylhet district in Bangladesh where first three indicators regarding rainfall: consecutive dry days (CDD), consecutive wet days (CWD), and annual total wet-day precipitation (PRCPTOT) are computed by using RclimDex statistical modeling toolkit. And, the other three indicators: moderate rainy days (MRD), heavy rainfall days (HRD), and very heavy rainfall days (VHRD) are calculated using spread sheet analysis. The result shows that out of nine indicators for temperature only two indicators cool days and cool nights have the decreasing trend which signifies that temperature is increasing. And, from the precipitation indicator analysis, it is clear that consecutive dry days is increasing where consecutive wet days is decreasing with the decreasing trend of annual total wet day rainfall. Therefore, it is a threat to the Sylhet area as maximum rainfall of Bangladesh occurs at Sylhet.

Keywords: *Climate extreme, trend analysis, temperature, rainfall, climate change*

1. INTRODUCTION

Trend analysis is most commonly used to monitor, forecast and evaluate the rates of occurrences and or values associated with a particular event. On the other hand, climate change can be defined as a trend in one or more climatic variables characterized by a fairly smooth continuous increase or decrease of the average value during the long period of record. There are several study has been conducted relevant to the climate change and climate variability on the basis of trend analysis of climatic variables such as precipitation, temperature, humidity, wind pattern, solar radiation, etc. and with the linkage of change in hydrological extreme event such as flood, drought, cyclone frequency even on demographic change (Rabbani et al., 2011; Chowdhury et al., 2012; Hasan et al., 2012; Shah and Hasan, 2014; Nury et al., 2014). In most of the cases the researchers uses different statistical software or spread sheet analysis to find out the change of the climatic variables minimum, mean, maximum data. In this study both RClimDex software and spread sheet analysis have been used but the speciality of this study is to assess the changes in extremes on the basis of trend of climate indices for Sylhet district. Though Sylhet region is not such vulnerable to drought but there is an indication of change in weather pattern (Shah and Hasan, 2014).

This study deals with 12 climate indices out of 27 core indices developed by Expert Team on Climate Change Detection and Indices (ETCCDI). Those climate indices are widely used as a tool to assess and monitor changes in extremes (Peterson and Manton, 2008). Even projections of the changes in these indices are indicative of the future climate change in extremes (Tank et al., 2009). In concern with the mitigation and adaptation regarding climate change, it is necessary to understand the realty of the occurrence of climate change based on observed historical hydro-meteorological data. And, it is difficult to understand from the large volume of historical data of hydro-meteorological variable, thus climate indices is a way by statistical analysis of variations of climatic variables and comparison of time series, means, extremes and trends. For the understanding of the effects of climate change and taking initiative on impact assessment, mitigation & adaptation regarding climate change.

2. STUDY AREA

Sylhet is located on the banks of the Surma River and is surrounded by the Jaintia, Khasi and Tripura hills (SCC, 2015). The absolute location of Sylhet city is at 24.8917°N 91.8833°E, in the north eastern region of Bangladesh (LGED, 2015). Figure 1 shows the location of the study area. The city has a high population density, with nearly 500,000 people (SCC, 2015). The climate of Sylhet is tropical monsoon with a predominantly hot and humid summer and a relatively cool winter (SCC, 2015). The city is within the monsoon climatic zone, with annual average highest temperatures of 23 °C (Aug-Oct) and average lowest temperature of 7 °C (Jan). Nearly 80% of the annual average rainfall of 3,334 mm occurs between May and September (LGED, 2015).

The physiography of Sylhet comprises mainly of hill soils, encompassing a few large depressions known locally as "beels" which can be mainly classified as oxbow lakes, caused by tectonic subsidence primarily during the earthquake of 1762. The area covered by Sylhet Division is 12,569 km², which is about 8% of the total land area of Bangladesh (SCC, 2015). Geologically, the region is complex having diverse geomorphology; high topography of Plio-Miocene age such as Khasi and Jaintia hills and small hillocks along the border. At the centre there is a vast low laying flood plain, locally called Haors (LGED, 2015). Haors, also known as the Sylhet basin, are a wetland ecosystem, which is a natural bowl-shaped depression and mainly can be found in the Sylhet region, in particular also in Sylhet Sadar (SCC, 2015).

Figure 2: Location map of the study area

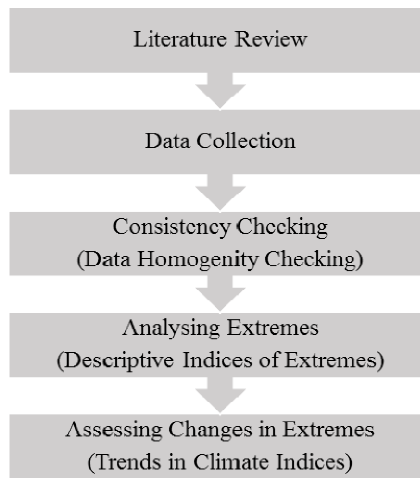


Figure 1: Methodological flow chart

3. METHODOLOGY

Relevant documents, reports and publications have been reviewed to develop the simplest methodology of this study. This study has been conducted on the basis of secondary source data from Bangladesh Meteorological Department (BMD). Sylhet station is one of hydro-meteorological station of BMD. Daily observed rainfall and temperature data for the Sylhet station has been collected for the period 1961–2010 as climate variable of at least daily temporal resolution of long term high quality and reliable records is important to account the changes in extremes (Tank et al., 2009).

Data consistency checking has been done on visual screeing of the plot of daily rainfall, min temperature and max temperature. As climate data are most of the cases shows variations by jumps or gradual shifts for different cases such as gauge location change, exposure of environment and manual or instumental error of data collection (Vincent et al., 2001; Tank et al., 2009). However rainfall and temperature data for the Sylhet station shows relatively homogeneous. For the analysis of extremes using descriptive indices and the assessing the changes in extremes using trend analysis has been done with the open source software RclimDex. The statistical software RclimDex has a graphical user interface to compute 27 core descriptive indices defined by the ETCCDI (Zhang and Yang, 2004). The concept of the indices is to compute the number of days in a year exceeding the defined specific thresholds value. (WMO, 2007; Peterson and Manton, 2008; Tank et al., 2009). For this study nine indices of temperature and three indices of rainfall has been asseses out of 27 core of set of indices of ETCCDI. And other three indices are computed using the spread sheet analysis of Microsoft Excel. Description of these fifteen indices represented in the Table 1 and 2. Overall approach and methodology of this study is depicted in the flowchart shown in Figure 2.

Table 1: List of temperature indicators

SL	Indicators (units)	Notation	Definition
1	Summer days (days)	SU25	Annual count when TX (daily maximum temperature) >25^{0}C
2	Tropical nights (days)	TR20	Annual count when TN (daily minimum temperature) >20^{0}C
3	Max Tmax (^{0}C)	TXx	Monthly maximum value of daily maximum temperature
4	Max Tmin (^{0}C)	TNx	Monthly maximum value of daily minimum temperature
5	Min Tmax (^{0}C)	TXn	Monthly minimum value of daily maximum temperature
6	Min Tmin (^{0}C)	TNn	Monthly minimum value of daily minimum temperature
7	Cool days (days)	TX10p	Count of days when TX<10th percentile
8	Warm days (days)	TX90p	Count of days when TX>90th percentile
9	Cool nights (days)	TN10p	Count of days when TN<10th percentile

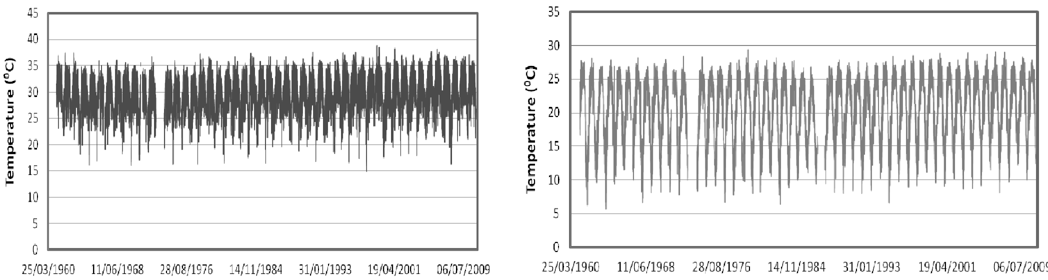
Table 2: List of precipitation indicators

SL	Indicators	Notation	Definition
1	Consecutive dry days	CDD	Maximum number of consecutive days with daily precipitation <1mm
2	Consecutive wet days	CWD	Maximum number of consecutive days with daily precipitation ≥1mm
3	Annual total wet-day precipitation	PRCPTOT	Annual total precipitation in wet days (daily precipitation ≥1mm)
4	Moderate rainy days	MRD	Number of days with daily rainfall ranging from 5mm to 100mm
5	Heavy rainfall days	HRD	Number of days with daily rainfall above 100mm and less than 150mm
6	Very heavy rainfall days	VHRD	Number of days with daily rainfall above 150mm

4. RESULTS AND DISCUSSION

4.1 Homogeneity of Temporal Meteorological Data

The historical time series data of rainfall and temperature for the Sylhet station has been plotted to check the homogeneity in visual screening. Figure 3 and 4 show that there are some data gap in rainfall and temperature series but over all the data for the Sylhet station is homogeneous as there is no abrupt shift or jump.



(a) (b)

Figure 3: a) Daily maximum temperature b) Daily minimum temperature of Sylhet station

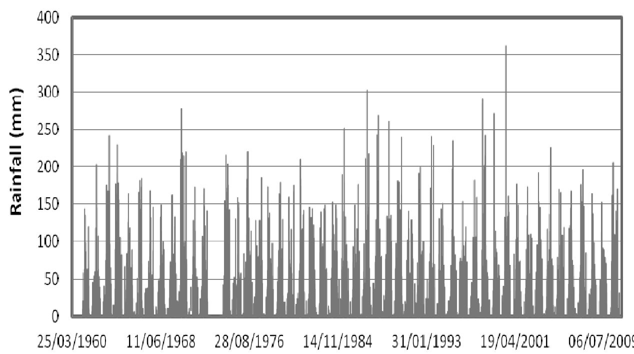
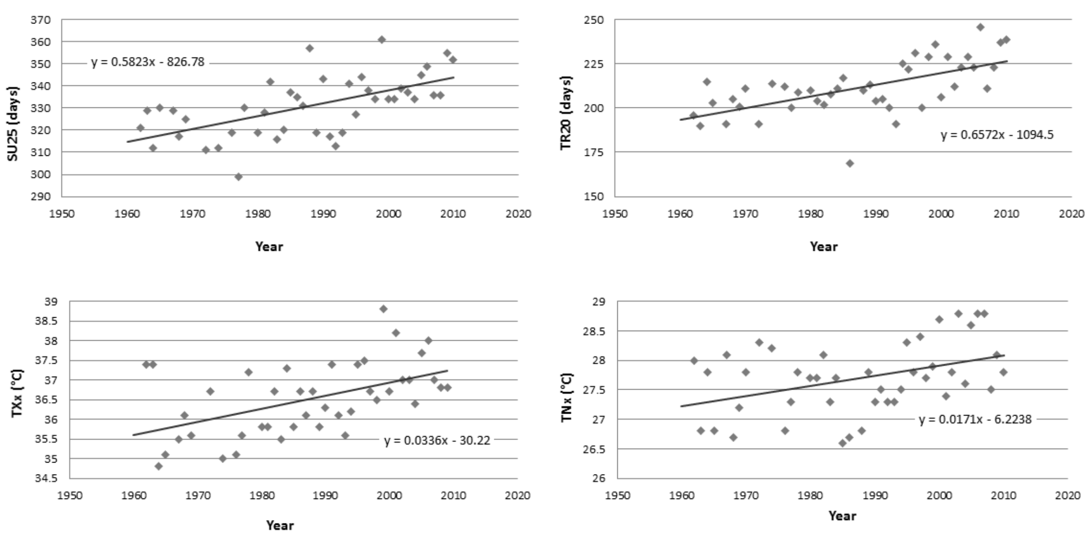


Figure 4: Daily accumulated rainfall of Sylhet station

4.2 Analysing Extremes

To observe uniform perspective and monitoring changes in weather and climate extremes, ETCCDI has been defined the core set of descriptive indices. The conceptualization of the indices represents mostly the number of day count in a year exceeding the specified threshold value. Figure 5 shows the plotting of all 15 indices.



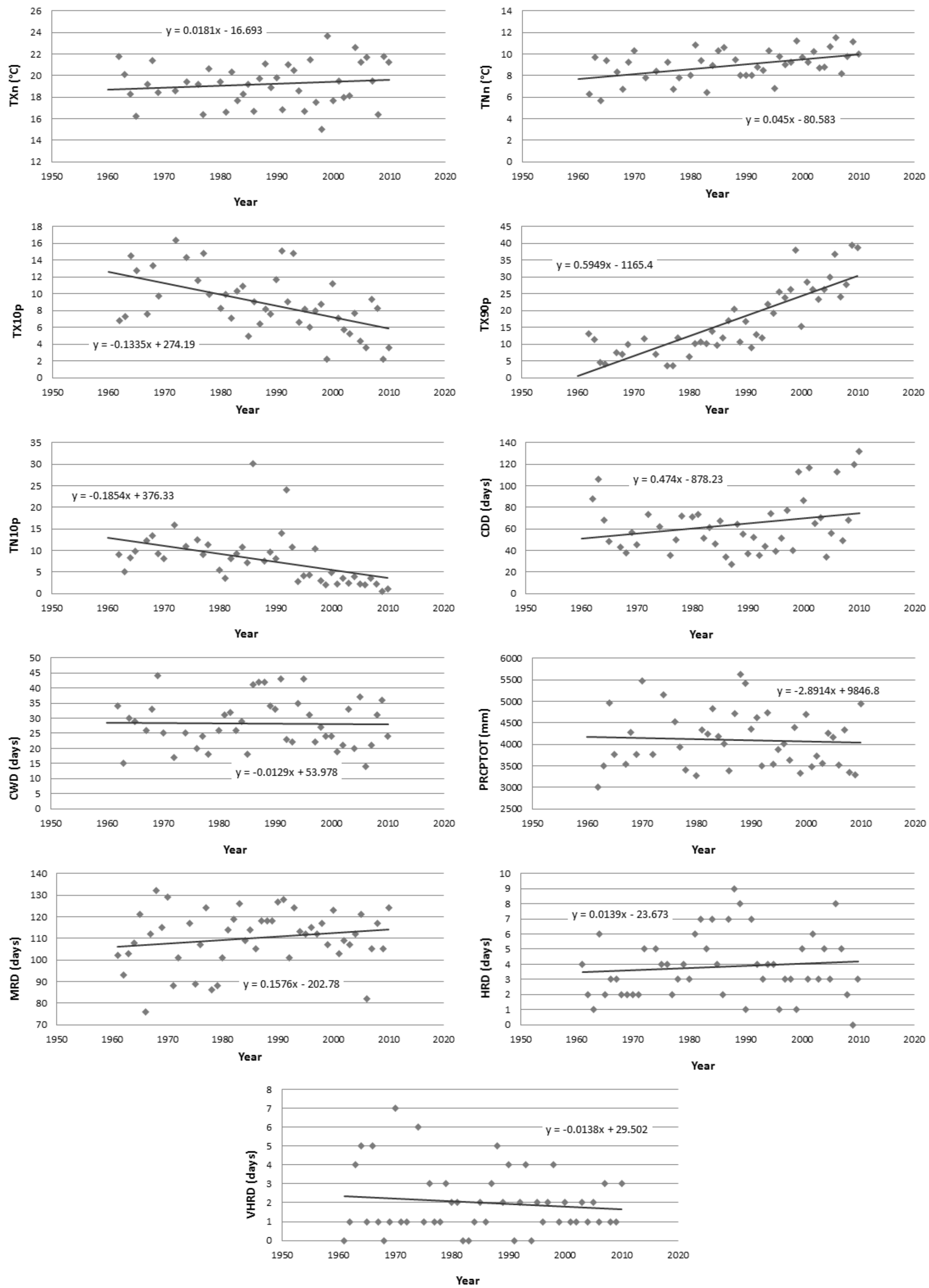


Figure 5: Plotting of the fifteen climate indices of Sylhet station

All of these fifteen indices are internationally co-ordinated indices which analyse the extremes of moderate temperature and precipitation in different aspects including frequency, intensity and duration.

4.3 Assessing changes in Extremes

The slope of the linear trend illustrates the change of variable over long given period. Overall result of the trend analysis is represented in the following Table 3 and 4 and illustrate in
Figure 6. The trend of the temperature indices represents there are decreasing trend of cool days (TX10p) and cool nights (TN10p). Other seven indices show the increasing trend which illustrate overall rising of temperature in the Sylhet district.

Again for rainfall indices consecutive wet days, annual total precipitation is decreasing and consecutive dry days are increasing which is indication of probable increase of dry day during summer season and total precipitation decrease will signify the decrease in precipitation, one of major source of water. And it is also observed that, moderate and heavy rainfall day are increasing which may increase the trend of rainfall induced flood.

Table 3: Result of trend analysis of temperature indices

SL	Indicators (units)	Notation	Data Range	Slope	SD	P-Value
1	Summer days (days)	SU25	1960 - 2010	0.582	0.121	0
2	Tropical nights (days)	TR20	1960 – 2010	0.657	0.131	0
3	Max Tmax (0C)	TXx	1960 – 2010	0.033	0.009	0
4	Max Tmin (0C)	TNx	1960 – 2010	0.017	0.006	0.007
5	Min Tmax (0C)	TXn	1960 – 2010	0.018	0.022	0.407
6	Min Tmin (0C)	TNn	1960 – 2010	0.045	0.014	0.002
7	Cool days (days)	TX10p	1960 – 2010	-0.133	0.033	0
8	Warm days (days)	TX90p	1960 – 2010	0.595	0.063	0
9	Cool nights (days)	TN10p	1960 - 2010	-0.185	0.057	0.002

Table 4: Result of trend analysis of precipitation indicators

SL	Indicators (units)	Notation	Data Range	Slope	SD	P-Value
1	Consecutive dry days	CDD	1960 - 2010	0.474	0.272	0.089
2	Consecutive wet days	CWD	1960 – 2010	-0.013	0.088	0.884
3	Annual total wet-day precipitation	PRCPTOT	1960 – 2010	-2.891	7.136	0.687
4	Moderate rainy days	MRD	1960 – 2010	0.158		
5	Heavy rainfall days	HRD	1960 – 2010	0.014		
6	Very heavy rainfall days	VHRD	1960 – 2010	-0.014		

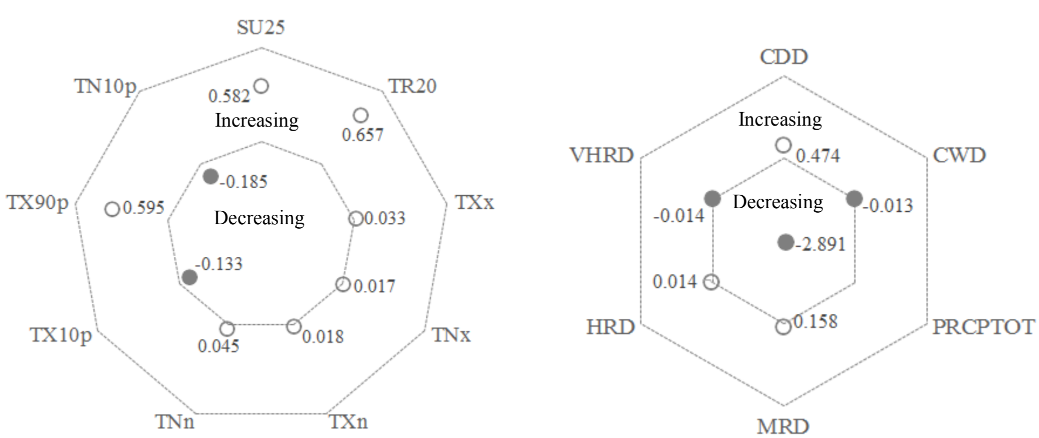


Figure 6: Trend of temperature and rainfall indices for Sylhet station

5. CONCLUSIONS

Any change in the frequency or severity of the extreme climate event has a severe impact on nature and society thus analysing extreme event is very important in the climate community. Though, it is difficult to attribute directly to the single extreme event for anthropogenic climate change. But there is an indication of human contribution to increase the temperature and precipitation extremes which could be possible to address with data availability and implication of knowledge (Tank et al., 2009).

The major outcome of this study is the analysis of extremes and trend analysis of the changes in extremes which is a contribution to the climate-policy related research at the local and national scales. Water resources planners in local authorities and national decision makers can use the result for the assessment of climate change along with the formulation of adaptation and mitigation strategies. This trend analysis will help for the assessment of hazard and risk of area as Bangladesh is an agricultural country and vulnerable to natural disaster by hydro-meteorological extremes such as flood, drought, cyclones, due to the change in climate extremes (Hasan et al., 2012).

However, this study reveals that climate change impact needed to be analysed for this area as the trend analysis resembles the significance change of climate extremes though one station data is not adequate to represent the entire scenario of the total area. But for less opportunity of data gathering, this study at least gives the concept of analysing technique, dealing with multiple recognized indices and indicating the need of trend analysis. The indices assessed in this study are also widely used for monitoring changes in extremes, climate model evaluation and assessments of future climate.

REFERENCES

Chowdhury, A.F.M.K., Ahmed, S. & Chowdhury, M. A. I. (2012). Trends of climatic variables (rainfall and temperature) at Sylhet, Bangladesh. *SUST Journal of Science and Technology*, 19(5), 87–93.

Hasan, G.M.J., Alam, R., Islam, Q.N. and Hossain, M.S. (2012). Frequency structure of major rainfall events in the North-Eastern part of Bangladesh. *Journal of Engineering Science and Technology*, 7(6), 690-700.

LGED (2015). http://www.lged.gov.bd/DistrictLGED.aspx?DistrictID=61. Accessed on 25 June 2015.

Nury, A.H., Koch, M. & Alam, M.J.B. (2014). Analysis and prediction of time series variations of rainfall in north-eastern Bangladesh. *British Journal of Applied Science & Technology*, 4(11), 1644-1656.

Peterson, T.C. & Manton, M.J. (2008). Monitoring changes in climate extremes-A tale of international collaboration, retrieved from http://journals.ametsoc.org/doi/pdf/10.1175/2008BAMS2501.1

Rabbani, G., Rahman, A.A. & Islam, N. (2011). Climate change implications for Dhaka city: A need for immediate measures to reduce vulnerability. "Resilient Cities: Cities and Adaptation to Climate Change." Proceedings of the Global Forum 2010: Local Sustainability, K. Otto-Zimmermann, Vol. 1, 531-541.

SCC (2015). http://www.sylhetcitycorporationbd.org/index.php/cms/about_sylhet/#. Accessed on 25 June 2015.

Shah, S.M.A. and Hasan, G.M.J. (2014). Statistical analysis and trends of dry days in Sylhet region of Bangladesh. *Journal of Urban and Environmental Engineering*, 8(1), 48-58.

Tank, A.M.G.K., Zwiers, F.W. & Zhang, X. (2009). Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation. Climate Data and Monitoring WCDMP-No. 72. World Meteorological Organization, Geneva, Switzerland. Retrieved from http://www.wmo.int/pages/prog/wcp/wcdmp/wcdmp_series/documents/WCDMP_72_TD_1500_en_1.pdf

Vincent, L.A., Zhang, X., Bonsal, B.R., Hogg, W.D. (2001). Homogenization of daily temperature over Canada. *Journal of Climate*, 15, 1322-1334.

WMO (2007). Joint CCL/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices, World Climate Data and Monitoring Programme (WCDMP), ICPO Publication Series No. 115, Retrieved from http://www.clivar.org/sites/default/files/documents/115_etccdi2.pdf

Zhang, X. and Yang, F. (2004). User Manual, RClimDex (1.0), Climate Research Branch Environment Canada Downs view, Ontario Canada.