STUDY ON THE STATISTICAL CHARACTERIZATION OF CLOUD COVER IN RELATION TO SELECTED CLIMATIC PARAMETERS

by

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CERTIFICATE OF APPROVAL

The thesis titled **"Study on the Statistical Characterization of Cloud Cover in Relation to Selected Climatic Parameters"**, submitted by Mohammad Jahangir Hossain, Roll No. 1009162022, Session: October 2009, has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Engineering in Water Resources Engineering on 31 March 2015.

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This is to certify that this project work entitled **“study on the statistical characterization of cloud cover in relation to selected climatic parameters’’** has been done by me under the supervision of Dr. Md. Sabbir Mostafa Khan, Professor, Department of Water Resources Engineering, Bangladesh University of Engineering and Technology, Dhaka. I do hereby declare that this project or any part of it has not been accepted elsewhere for the award of any degree or diploma from any other institution.

Signature of the candidate

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(Mohammad Jahangir Hossain)

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Abbreviation

BMD	Bangladesh Meteorological Department
BUET	Bangladesh University of Engineering and Technology
ęC	Degree Centigrade
ET	Evapotranspiration
GIS	Geographic Information System
m/s	meter per second
MSE	Mean Square Error
NSC	Nil Significant Cloud
RF	Rainfall
R_h	Relative Humidity
SKC	Sky Clear
SWC	Surface Warning Centre

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Abstract

The rate of cloud coverage in the sky is influenced by different climatic factors. Thatôs why, Cloud coverage and other climatic parameters related to it such as temperature, rainfall and relative humidity of Bangladesh is the main objective of this study.

Data (1953 ï 2011) of thirty five meteorological stations of Bangladesh have been collected to achieve the objectives. The source of these climatic data is the Bangladesh Meteorological Department (BMD). At first the data were processed by using tools Microsoft Office Access 2003. All the climatic data of different locations are analyzed in the basis of monthly, yearly and seasonally.

It is identified from analysis that in Bangladesh large amount of cloud coverage occurs from the month of June to September and in July it is maximum. In July, about seven eighth portions of the sky are covered by cloud. Small amount of cloud coverage occurs from the month of November to May and minimum in the months of December and January. In the month of January and December, only one eighth portions of the sky are covered by the cloud. Clouds begin to form from the month of February and in July the cloud formation is in large extent. Again cloud formation starts to diminish from the month of September and in December and January the formation is in little extent. In Monsoon season cloud formation is high but it is low in Dry season in most of the districts of Bangladesh. Annual variation trend at different location represents that maximum cloud coverage occurs in Sylhet and minimum in Dinajpur. In Bangladesh temperature is maximum in April or May and is minimum in January. The average monthly temperature of the country varies from 9ęc to 37ęc. Maximum average temperature occurs in monsoon seasons (June to October) and minimum average temperature occurs in dry season (November to February). The average annual humidity in Bangladesh is 79.52%. In most of the location heavy amount of humidity occurs from the month of June to October and in July it is maximum but in March it is minimum. The range of relative humidity varies from 58.56% to 89.9%. From analysis, it is found that the average annual total rainfall of the country is about 2394.28 mm. Heavy rate of rainfall occurs in the months of June, July and August at the time of full monsoon and in July the rate is maximum. Minimum rate of rainfall occurs in the months December and January. Average annual maximum rainfall occurs in Teknaf (4065.241 mm) and Sylhet (4016.286 mm) and minimum rainfall occurs in Rajshahi (1484.92 mm). The correlation coefficient (r) between cloud cover with temperature, humidity and rainfall is large and positive. It means cloud cover rate is increased with the increasing value of temperature and humidity. It also means rainfall rate increases with the increasing of cloud cover in the sky.

CHAPTER 1
INTRODUCTION

1.1. BACKGROUND OF THE STUDY

A cloud is a mass of water drops or ice crystals suspended in the atmosphere. Clouds form from water in the sky. The water may evaporate from the ground or move from other areas. Water vapor is always in the sky in some amount but is invisible. Clouds form when an area of air becomes cooler until the water vapor there condenses to liquid form. At that point, the air is said to be "saturated" with water vapor. The air where the cloud forms must be cool enough for the water vapor to condense. The water will condense around things like dust, ice or sea salt - all known as condensation nuclei. The temperature, wind and other conditions where a cloud forms determine what type of cloud it will be. (NASA, 2013)

Clouds are categorized primarily by two major factors - location and shape. High clouds form several kilometers up in the sky, with the exact height depending on the temperatures where they form. Low clouds generally form within a kilometer or two of Earth's surface. In fact, low clouds can even form touching the ground, when they are called fog. Middle-level clouds form between low and high clouds. Cirrus clouds are thin and wispy and often curve with the wind. Cumulus clouds tend to be big and fluffy. These clouds look kind of like giant cotton balls or other shapes in the sky. As a middle-level cloud, this type also can form parallel stripes of clouds. Stratus clouds form sheets of clouds that cover the sky. (NASA, 2013)

Most of the water in clouds is in very small droplets, but sometimes those droplets collect more water. Then they turn into larger drops. When that happens, gravity causes them to fall through the air faster. The falling water drops are rain. When it is colder, the water may form snowflakes instead. Clouds also can cause freezing rain or sleet. These happen when snow melts on the way to ground but then gets colder again. Hail falls during more severe weather. Air currents cause rain and snow to move around in the sky. As they move, they get colder and turn into ice. As they move, the ice chunks get bigger. Finally, they fall to the ground as hail. (NASA, 2013)

Clouds are important for many reasons. Precipitation, like rain or snow, is one of those reasons. At night, clouds reflect heat back to the surface and keep it warmer. During the day, clouds can shade us from the sun and keep the earth cooler. (NASA, 2013)

Clouds are made up of many millions of miniscule water droplets which are formed when moist warm air rises up into the sky and is then cooled down. If the cloud is very cold it means that it is made up of ice crystals. (Weather-facts, 2008)

Condensation or Deposition of water above the Earth's surface creates clouds. In general, clouds develop in any air mass that becomes Saturated (relative humidity becomes 100%). Saturation can occur by way of atmospheric mechanisms that cause the temperature of an air mass to be cooled to its dew point or frost point. Different mechanisms or processes can achieve this outcome causing clouds to develop: (1). Orographic uplift occurs when air is forced to rise because of the physical presence of elevated land. As the parcel rises it cools as a result of adiabatic expansion at a rate of approximately 10° Celsius per 1000 meters until saturation. The development of clouds and resulting heavy quantities of precipitation along the west coast of Canada are mainly due to this process. (2). Convectional lifting is associated with surface heating of the air at the ground surface. If enough heating occurs, the mass of air becomes warmer and lighter than the air in the surrounding environment, and just like a hot air balloon it begins to rise, expand, and cool. When sufficient cooling has taken place saturation occurs forming clouds. This process is active in the interior of continents and near the equator forming cumulus cloud and or cumulonimbus clouds (Thunderstorms). The rain that is associated with the development of thunderstorm clouds is delivered in large amounts over short periods of time in extremely localized areas. (3). Convergence or frontal lifting takes place when two masses of air come together. In most cases, the two air masses have different temperature and moisture characteristics. One of the air masses is usually warm and moist, while the other is cold and dry. The leading edge of the latter air mass acts as an inclined wall or front causing the moist warm air to be lifted. Of course the lifting causes the warm moist air mass to cool due to expansion resulting in saturation. This cloud formation mechanism is common at the mid-latitudes where cyclones form along the polar front and near the equator where the trade winds meet at the intertropical convergence zone. (4). Radiative cooling occurs when the Sun is no longer supplying the ground and overlying air with energy derived from solar insolation (e.g., night). Instead, the surface of the Earth now begins to lose energy in the form of long wave radiation which causes the ground and air above it to cool. The clouds that result from this type of cooling take the form of surface fog. Of course these causes of cloud development do not always act in a singular fashion. It is possible to get combinations of all four types, such as when convection and orographic uplift cause summer afternoon cloud development and showers in the mountain. (Pidwirny, 2006)

Clouds are made up of minute water droplets or ice crystals that condense in the atmosphere. The creation of a cloud begins at ground level. As the Sun heats Earth's surface, the warmed ground heats the surrounding air, which then rises. This air contains variable amounts of water vapor that has evaporated from bodies of water and plants on Earth's surface. As the warmed ground-level air rises, it expands, cooling in the process. When the cooled air reaches a certain temperature, called the dew point, the water vapor in the air condenses into tiny microscopic droplets, forming a cloud. If condensation occurs below the freezing point (32°F; 0°C), ice crystals form the cloud. Clouds appear white because sunlight reflects off the water droplets. Thick clouds appear darker at the bottom because sunlight is partially blocked. (UXL Encyclopedia of Science, 2002)

Cloud cover (also known as cloudiness, cloudage or cloud amount) refers to the fraction of the sky obscured by clouds when observed from a particular location. And

Okta, a unit of measurement used to describe cloud cover. In meteorology, an okta is a unit of measurement used to describe the amount of cloud cover at any given location such as a weather station. Sky conditions are estimated in terms of how many eighths of the sky are covered in cloud, ranging from 0 oktas (completely clear sky) through to 8 oktas (completely overcast). Although relatively straightforward to measure (visually for instance, by using a mirror), oktas only estimate cloud cover in terms of the area of the sky covered by clouds. They do not account for cloud type or thickness, and this limits their use for estimating cloud albedo or surface solar radiation receipt. (Wikipedia, 2014)

Clouds can cool the surface by reflecting solar energy back into space, and can warm it by radiating heat energy back down to the surface. The balance of those two processes depends on many factors, including wind speed, turbulence, humidity and cloud ñthickness,ò or liquid water content. (Kevin woolsey, 2013)

Clouds are important for many reasons. Precipitation, like rain or snow, is one of those reasons. At night, clouds reflect heat back to the surface and keep it warmer. During the day, clouds can shade us from the sun and keep Earth cooler. Studying clouds helps NASA better understand Earth's weather and climate. NASA uses satellites in space as well as computers to study clouds. NASA also studies clouds on other planets. Mars has clouds that are similar to some clouds on Earth. Other planets have clouds made of materials other than water. For example, Saturn's moon Titan has clouds of methane and ethane. Jupiter has clouds made of ammonia. (NASA, 2013)

Clouds are a very important part of the earth-atmosphere system. They affect and are a part of a multitude of processes. The radiation budget is affected by clouds because of mainly their reflectance of the incoming shortwave radiation, and their re-emittance of the long wave radiation back to the surface. The distribution of clouds can affect the radiation budget which may change the local and global surface temperature. This change of temperature may in turn have an effect on the global cloud distribution. Clouds are also important for certain chemical processes. The most notable example of this is polar stratospheric clouds, which allow heterogeneous chemical reactions to occur on the droplet surface and ultimately leads to the destruction of ozone. Clouds are also incredibly important in the water cycle, because clouds transport quite a bit of water through the atmosphere and clouds also are where water condenses and falls back to earth. One last phenomenon, which clouds are necessary for, is lightning. (Dave Rahn, 2001)

Clouds both reflect incoming sunlight and inhibit the radiation of heat radiation from the surface, thereby affecting both sides of the global energy balance equation. Clouds also produce precipitation from water vapor, releasing heat to the atmosphere in the process (evaporation of water vapor from the surface cools it, so that these two processes serve to transfer heat from the surface to the atmosphere). Thus, any changes in clouds will modify the radiative energy balance and water exchanges that determine the climate. The trouble is that clouds are produced by the climate, specifically the atmospheric motions (winds) that are produced by the radiative and latent heating influenced by clouds. This connected loop of relations is called a feedback loop. The ways that clouds respond to changes in the climate are so complex that it is hard to determine their net effect on the energy and water balances and to determine how much climate might change. The balance between absorbed solar radiation and emitted heat radiation sets the temperature of Earth. For example, when heat radiation from the surface slows, as caused by increasing greenhouse gas abundances, the balance can only be maintained if the temperature rises. Changing clouds can alter this relation, either increasing or decreasing the magnitude of the resulting temperature increase. Also, when clouds change, precipitation will change, which will affect the supply of freshwater to the land. Right now, we do not know how important the cloud-radiative or cloud-precipitation effects are and cannot predict possible climate changes accurately. (NASA, 2013)

Clouds are also part of another important internal heat exchange process involving water phase changes. Most of Earth's "free" water is in the oceans (even more water is contained in the rocky crust of Earth), equivalent to a layer covering the whole surface about 2.5 km deep. Another 50 m of water is currently stored in the major ice sheets in Greenland and Antarctica. The atmosphere only contains about 2.5 cm of water and clouds contain only 0.05 mm. When water evaporates from the ocean and land surface, it cools the surface because it takes energy to change liquid/solid water into vapor. The atmospheric circulation transports water vapor from place to place. When the atmospheric motions include upward motions, the air cools and clouds form by condensing water vapor back to liquid/solid form. If the clouds produce no precipitation, then the energy released by the condensation of the cloud water is recaptured by the water vapor when the cloud water evaporates. However, if the clouds produce rain/snow, the energy released by the condensation heats the atmosphere. Because of the atmospheric transport of water vapor, the precipitation does not locally balance the evaporation, so the water vapor transport is equivalent to energy transport. The average evaporation and precipitation rates mean that all the water in the atmosphere is exchanged about once every 10 days. There is also a net transport of about 10% of the total water vapor evaporated from the oceans to the land, most of which is then returned to the oceans by rivers. Thus, the water cycle links the two parts of the radiation balance: the surface is heated by sunlight and cooled by water evaporation, but the atmosphere is heated by precipitation and cooled by terrestrial radiation to space. This water cycle is even more important to us because the small amount of water that is contained lakes and rivers or retained in underground water is our only supply of fresh water for drinking, agriculture and many other industrial and recreational uses. (NASA, 2013)

The variation of cloud cover and other climatic parameter related to cloud such as temperature, relative humidity and rainfall of Bangladesh is the major concern of the study. This study also focused on the establishment of correlation between cloud cover with other climatic parameter such as temperature, relative humidity and rainfall in context of Bangladesh during different seasons and different locations.

1.2. OBJECTIVES OF THE STUDY

Specific objectives:

1. To analyze variation and trend of cloud cover monthly, seasonally and annually all over Bangladesh
2. To compute correlation coefficients and formulate regression equations for the amount of cloud cover with other climatic parameters such as temperature, rainfall, humidity etc

Possible outcome:

1. Monthly, seasonal and annual variation of cloud cover
2. Monthly, seasonal and annual trend of cloud cover
3. Statistical correlation among cloud cover and other climatic parameters such as temperature rainfall, humidity etc.

1.3. ORGANIZATION OF THE THESIS

Water Resource Engineering Department, Bangladesh University of Engineering and Technology, Dhaka.

CHAPTER 2
LITERATURE REVIEW

2.1. General

In the past, all over the world many studies and researches have been carried out on cloud and other meteorological parameters. In this chapter some of the pioneering works of past researchers have been summarized in order to gain in depth knowledge on different meteorological parameters and the physical process involved behind the parameters, so that the study objectives can be fulfilled having proper conception about past knowledge.

2.2. Synopsis of some of the study report

A synopsis of some of the study report is given below:

Lowe (2011) statistically analyzed the relationship between cloud cover and temperature in Australia at certain times of the day. The Australian Bureau of statistics provided good data on this, and he was able to measure the level of cloud cover as a variable over certain times of the day. He used Australiaꞌs cloud cover data from 1950 until current. From about 1996 to current for midnight, and from 2000 to current for 3am, limited data was available for cloud cover. His analysis was not only at maximum and minimum temperatures, but also at time based temperatures, which are a better more consistent representation for temperature analysis. He used 21 weather stations around Australia that had accurate and consistent time based temperature data from 1950 onwards. He had 8 time based temperature since 1950 for Midnight, 3am, 6am, 9am, Noon, 3pm, 6pm and 9pm. It must be noted that for some reason the amount of data for 9pm was less than the other time variables. For his analysis he used better mathematical method and some statistical softwareꞌs such as MS Excel and SPSS software.

Hahn et. al (1994) have developed a cloud data set from synoptic weather reports over the globe for the 10 year period from December 1981 to November 1991. This period was chosen to correspond with the International Satellite Cloud Climatology Project

(ISCCP; Rossow and Schiffer, 1991). The data set was constructed to facilitate cloud analysis by removing or correcting inconsistent and erroneous reports, and by including only information from the synoptic weather report pertaining directly to clouds. Corrections are encoded in the Edited Cloud Report (ECR) such that the original report can be reconstructed. Extensive quality control measures were taken to ensure the reliability of the data set; those pertinent to the climatology presented herein are given: (a) Nighttime cloud reports made under conditions of insufficient moonlight are flagged. (b) If the sky was obscured due to fog, thunderstorms, drizzle (rain or snow), the sky was considered overcast. (c) Consistency checks were made to ensure that: i) low cloud amount is not larger than the total cloud cover ii) precipitation is not reported with clear sky iii) if cloud is reported, the type must be indicated in at least one of the 3levels iv) cloud amount and type are given or correctable.

Stephens (1978) employed a detailed multiple-scattering model to investigate the sensitivity of radiation profiles and flux divergences to changes in macrostructure and microstructure of basic water cloud types. The study had been performed on a range of cloud types including variable distributions of liquid water content (LWC) and drop-size distributions. To perform his activity he had to follow three steps. First, he established the radiation fields and the sensitivity of such things as flux divergence and cloud albedo on cloud macrostructure and microstructure using calculations by detailed theoretical models. Second, the results were checked using suitable experimental data and any uncertainties in the characteristics radiatively active constituents of the atmosphere identified. Finally, the detailed theoretical model and observational data were used as guide to the development and test of simple radiation-cloud parameterizations. In his work, eight basic drop-size distributions were introduced covering a wide range of shape and of liquid water content (LWC).

Peng and Zhang (2007) analyzed the characteristics of cloudiness variation and its possible causes over the Qinghai-Xizang plateau during 1971-2004. He focused on the interaction of total cloud amount (TC) with sunshine duration (S), diurnal temperature range (DTR), relative humidity (RH), precipitation (P). The data of total cloud cover were provided by Climatic Data Center at National Meteorological Information Center in China Meteorological Administration. It includes observed cloudiness information of 103 stations over the Qinghai-Xizang Plateau since their establishment. In order to screen for in homogeneities in the station records of cloudiness, only data over 1971-2004 was taken into account. Those stationǿs records displaying obvious jumps for station moving were excluded from the analysis, resulting in 75 retained stations. The spatial and temporal structure of total cloud cover was derived by analyzing standardized data using Empirical orthogonal function (EOF). The simple linear trends of annual and seasonal total cloudiness have been evaluated at each of the 75 stations. The correlation analysis and trend fitting were applied to discuss the relationship between cloudiness and other variables (S, DTR, RH, and P). Wei et al. (1997) observed different geographic and vertical distribution in winter and summer over the Qinghai-Xizang Plateau by using the data of the International Satellite Cloud Climatology Project (ISPPC).

Pincus (2008) described a methodology to evaluate the performance of CMIP3 climate models, by comparing the simulation of the present-day distribution of cloud fraction, radiation (top-of-atmosphere long-wave, short-wave and net radiative fluxes and top-of-atmosphere long-wave, short-wave and net cloud forcing) and surface precipitation rate, to global observations (primary and secondary datasets selected for each product being compared). A range of statistical parameters are defined in the text (RMS error, mean bias, centred RMS error, the ratio of the standard deviations and the correlation), however only two statistical parameters, namely the standard deviation and the correlation, are discussed at depth. It is stated that no individual model excels in all scores though ñthe IPCC mean modelò, constructed by averaging the fields produced by all the CMIP models, performs particularly well.

Williams and Webb (2009) assign model data to observed cloud regimes obtained from clustering histograms of cloud amount in joint cloud optical depth (tau)ï cloud top pressure (CTP) classes, with the aim to evaluate how well the cloud regimes are simulated in the global circulation models (GCMs). They use data from ten models submitted to the Cloud Feedback Model Intercomparison Project (CFMIP, http://www.cfmip.net) and the 3-hourly ISCCP D1 product to obtain the daily mean joint tauï CTP histograms of cloud amount. They state that detailed analysis of the cloud regimes provides model developers with considerable information on the weaknesses of the cloud simulation in their model. The results show that most of the global variance in the cloud radiative response between GCMs is due to low clouds with 47% due to the stratocumulus regime and 18% due to the regime characterized by clouds undergoing transition from stratocumulus to cumulus.

Marchand and Ackerman (2010) presents recent simulations using the multi scale modeling framework (MMF), in which a two-dimensional or small three-dimensional cloud resolving model is embedded into each grid cell of a climate model, against products from the ISCCP and from the Multi-angle Imaging Spectroradiometer (MISR). The products that are compared are joint histograms of cloud top height and optical depth from the MMF with same produced by the ISCCP and from the MISR. The paper points out that the two satellite dataset differ in both the satellite sensors and the algorithms used, with the result that the joint histograms can differ quite significantly even when viewing exactly the same clouds. The analysis shows that the MMF reproduces the broad pattern of tropical convergence zones, subtropical belts, and mid-latitudes storm tracks as observed by ISCCP and MISR. However, the model has several shortcomings as it significantly under predicts the amount of low level cloud in most regions.

Specific cloud detection algorithms have been developed for the Polar Regions by modifying the middle latitude schemes or by developing ǿad hocô algorithms. Key and Barry (1989) developed a method specifically for Arctic Advanced Very High

Resolution Radiometer (AVHRR) data, based on ideas of the International Satellite Cloud Climatology Project (ISCCP). They also used the Scanning Multichannel Microwave Radiometer (SMMR) in order to detect the ice edge and produce sea-ice masks. For each pixel, nine spectral features are analyzed and four surface (snow free land, snow-covered land, open water and sea ice) and three cloud classes are defined. The cloud classes are discriminated by the brightness temperature of channel 4, which is assumed as representative of the cloud top temperature. In a successive paper, Key (1990) used statistical parameters that consider the structural properties of clouds.

Lubin and Morrow (1998) tested the method developed by Ebert (1987) using summer AVHRR data and ship meteorological observations. The cloud classification method was applied to the 32×32 pixel cell centred about the shipǿs position during each satellite overpass. They defined 18 categories of surfaces and cloud types and they used eight spectral or textural features from the Ebert (1987) cloud classification method. The cloud classifications were compared with surface weather observations to determine whether the automated satellite cloud classifier could actually produce realistic descriptions of the scene. They concluded that a carefully applied pattern recognition technique could be used to produce good cloud climatology for the Arctic Sea.

Hughes (1984) gave a comparison between the satellite based cloud cover estimates and surface observation and their shortcomings. Early satellite based cloud climatologies were constructed by using satellite photographs and averaging and compositing visible brightness temperatures. Surface observation of clouds from land stations and from ships in ocean areas had been the major source of cloud cover data before the advent of airborne satellite measurements. Surface observations were taken on a regular basis over land but they were not uniform and very difficult to take during nighttime and over the oceans. Surface observations were taken on okta or tenths scale and overestimated the cloud amount as surface observers see the sides and the base of the clouds.

2.3. Summary

All over the world many studies and researches have been carried out on cloud and other meteorological parameters. Though many studies and researches have been carried out on different meteorological parameters in Bangladesh, but no successful study has been carried out on cloud or cloud cover and relation to other climatic parameters such as temperature, relative humidity, rainfall etc. For this, efforts have been given to collect the reports of different study relate to cloud cover and other climatic parameters like rainfall, temperature and relative humidity.

CHAPTER 3
THEORY AND METHODOLOGY

THEORY

3.1. Establishment of Correlation

In probability theory and statistics, correlation (often measured as a correlation coefficient) indicates the strength and direction of a linear relationship between two random variables. A number of different coefficients are used for different situations. The best known is the Pearson product-moment correlation coefficient, which is obtained by dividing the covariance of the two variables by the product of their standard deviations. The correlation coefficient is denoted as ñrò and the coefficient ranges from ï 1 to +1. The ñrò can be expressed mathematically as:

$$r^2 = \frac{\left[\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})\right]^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}$$

Where x_1, x_2.................x_n are Cloud cover data

$\bar{x}$ = is the average of all Cloud cover data

Where y_1, y_2...............y_n are any other climatic parameter

$\bar{y}$ = is the average of the other climatic data

n = total number of data set

A value of 1 shows that a linear equation describes the relationship perfectly and positively, with all data points lying on the same line and with Y increasing with X. A score of -1 shows that all data points lie on a single line but that Y increases as X decreases. A Value of 0 shows that a linear model is not needed, that there is no linear relationship between the variables.

To find out the co-relation between cloud cover and other climatic parameters (temperature, humidity and rainfall), at first the common location and the common period of data have been sorted out. The monthly average data for the period of 1975 to 2011 are considered to identify the relationship.

METHODOLOGY

3.2. DATA COLLECTION

Bangladesh Meteorological Department is the authorized Government organization for all meteorological activities in Bangladesh. It maintains a network of surface and upper air observatories, radar and satellite stations, agro-meteorological observatories, geomagnetic and seismological observatories and meteorological telecommunication system. The Department has its headquarters in Dhaka with two regional centers i.e. Storm Warning Centre (SWC), Dhaka and Meteorological and Geo-Physical Centre (M & GC), Chittagong.

For the purpose of the study, necessary climatic data such as i) Cloud Cover ii) Temperature iii) Relative Humidity and iv) Rainfall of the different locations of Bangladesh have been collected from BMD. The above mentioned climatic data of thirty five meteorological stations of BMD have been collected for the purpose of the study.

All the data are received in soft format. The summary of available climatic data is given in Appendix A.

Table 3-1: Station Information

Serial No	Station Name	Establishment	Station No	Latitude	Longitude	Elevation
1	Dhaka	1949	923	23.77	90.38	8.80
2	Tangail		909			
3	Mymensingh	1883	886	24.72	90.43	18.00
4	Faridpur	1883	929	23.60	89.85	8.20
5	Madaripur					
6	Syedpur		858			
7	Chandpur	1964	941	23.27	90.70	5.50
8	comilla	1883	933	23.43	91.18	6.10
9	Chittagong		977			
10	Coxôsbazar		992			2.10
11	Feni					
12	Rangamati	1957	966	22.53	92.20	62.50
13	Sandwip					
14	Sitakund					
15	Teknaf	1977	998	20.87	92.30	5.00
16	Maijdicourt	1951	953	22.87	91.10	4.90
17	Ambagan					
18	Kutubdia					
19	Hatia					
20	Bogra	1884	883	24.85	89.37	18.00
21	Rajshahi	1883	895	24.37	88.80	16.80
22	Ishurdi	1963	907	24.13	89.05	14.00
23	Khulna	1921	947	22.78	89.53	2.10
24	Chuadanga					
25	Jessore		936			
26	Satkhira	1871	946	22.72	89.08	4.00
27	Mongla					
28	Barisal	1883	950	22.75	90.37	2.10
29	Bhola					
30	Patuakhali	1973	960	22.33	90.33	1.50
31	Khepupara	1973	984	21.98	90.23	1.80
32	Sylhet	1952	891	24.90	91.88	33.50
33	Srimongal	1905	915	24.30	91.73	22.00
34	Dinajpur	1883	863	25.65	88.68	36.00
35	Rangpur	1883	859	25.73	89.23	32.60

3.2.1. CLOUD COVER

Bangladesh Meteorological Department determines the cloud amount of the sky at given location by using naked eye. The fraction of the sky obscured by clouds is observed from a particular location. In this case, Okta which is the usual unit of measurement used to describe the amount of cloud cover at any given location such as weather station. Sky conditions are estimated in terms of how many eighths of the sky are covered in cloud, ranging from 0 Oktas (completely clear sky) through to 8 Oktas (completely overcast). In addition, SYNOF code there is an extra cloud cover indication ñ9ò indicating that the sky is totally obscured (i.e. hidden from view), usually due to dense fog or heavy snow. Okta is used only to estimate cloud cover in terms of the area of the sky covered by clouds. It does not account for cloud type or thickness. Oktas are often referenced in Aviation weather forecasts and low level forecasts.

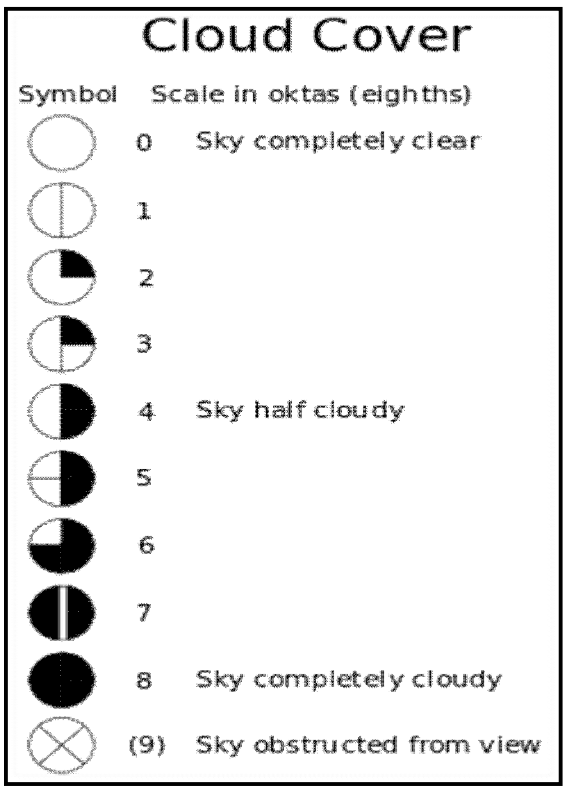


Figure: 3-1 (Source: SONA. web adresses: sonaspecs.zohosites.com)

SKC = Sky clear; FEW = 1 to 2 Oktas; SCT = 3 to 4 Oktas; BKN = 5 to 7 Oktas; OVC = 8 Oktas. NSC & CAVOK = Nil significant cloud. The status and availability of Cloud cover data is given in Table A1 of Appendix A.

3.2.2. TEMPERATURE

BMD is used four types of thermometer for temperature measurement. These are i) Dry bulb thermometer ii) Wet bulb thermometer iii) Maximum thermometer and iv) Minimum thermometer for the measurement of maximum and minimum temperature of the day. To determine the daily average temperature dry bulb thermometer is used. Maximum and minimum thermometers are used for determining daily maximum and minimum temperature. Wet bulb thermometer is required for measuring relative humidity.

Figure 3-2: Different Types of Thermometer, at BMD, Dhaka

Temperature data have been collected for thirty five stations for the time period of 1953 to 2011. These are the daily average temperature in degree centigrade (ęC). Besides these the monthly average maximum and monthly minimum temperature data are also collected. The status and availability of temperature data is given in Table A2 of Appendix A.

3.2.3. RELATIVE HUMIDITY

Hygrometers are instruments used for measuring relative humidity. A simple form of a hygrometer is specifically known as a psychrometer and consists of two thermometers, one of which includes a dry bulb and the other of which includes a bulb that is kept wet to measure wet-bulb temperature. Evaporation from the wet bulb lowers the temperature, so that the wet-bulb thermometer usually shows a lower temperature than that of the dry-bulb thermometer, which measures dry-bulb temperature. When the air temperature is below freezing, however, the wet bulb is covered with a thin coating of ice and yet may be warmer than the dry bulb. Relative humidity is computed from the ambient temperature as shown by the dry-bulb thermometers and the difference in temperature as shown by the wet-bulb and dry bulb thermometers. Relative humidity can also be determined by locating the intersection of the wet and dry-bulb temperatures on a psychometric chart. This instrument is setup in a secured compartment.

Figure 3-3: Wet Bulb Thermometer (Left) and Hygrograph (Right)

Relative humidity data are available for thirty five stations for the time period of 1953 to 2011. Relative humidity is also measured eight times in a day at an interval of three hours and data measurement starts from 12.00 A.M. The summary of relative humidity data is given in Table A3 of Appendix A.

3.2.4. RAINFALL

Rainfall data is measured by Manual Rain Gauge and Self Recording Rain Gauge by BMD.

Figure 3-4: Manual Rain Gauge, at BMD, at Dhaka

The manual rain gauge consists of a funnel attached to a graduated cylinder that fits into a larger container. If the water overflows from the graduated cylinder the outside container will catch it. So when it is measured, the cylinder will be measured and then the excess will be put in another cylinder and measured. A metal pipe is attached to the container and can be adjusted to censure the rain gauge is level. This pipe then fits over a metal rod that has been placed in the ground.

Figure 3-5: SR Rain Gauge, at BMD, Dhaka

The self recording or tipping bucket rain gauge consists of a large copper cylinder set into the ground. At the top of the cylinder is a funnel that collects and channels the precipitation. Self recoding rain gauge measures rainfall by means of electromagnetic signal.

Rainfall data is available for thirty five stations of Bangladesh for the time period of 1953 to 2011. Rainfall is measured on daily basis and unit is millimeter. The summary of rainfall data is shown in Table A4 of Appendix A.

3.3. DATA PROCESSING

The collected climatic data are in complex format which were not suitable for analysis from the original dataset. At first the data were processed by using tools Microsoft Office Access 2003 to convert the data into daily average time series data. All the climatic data were checked thoroughly, and then the daily of each station was plotted. From the visual observation the wrong data (abrupt values) have been discarded from the data set. Some common error were found in data set like negative value (-1) or starry (**) sign instead of real value. May be it was due to punching error. These types of error were also deleted from data set. These types of errors were corrected by proper analysis.

3.4. DATA ANALYSIS

All the climatic data of different locations are analyzed in the basis of monthly, yearly and seasonally. For seasonal variation the whole year is divided into three seasons based on the rainfall variation of Bangladesh. The southwest monsoon reaches full fury by July or August but it is most active from June to October. So this period is considered as monsoon season and the months March to May are considered as pre-monsoon. Again in dry season (November-February) as the monsoon diminish, the country starts a transition from soaking wet to almost bone-dry and the reliability of rainfall decreases sharply (Manalo 1976).

Table 3-2: Seasons in Bangladesh

Season	**Month**	
	From	**To**
Pre-Monsoon	March	May
Monsoon	June	October
Dry	November	February

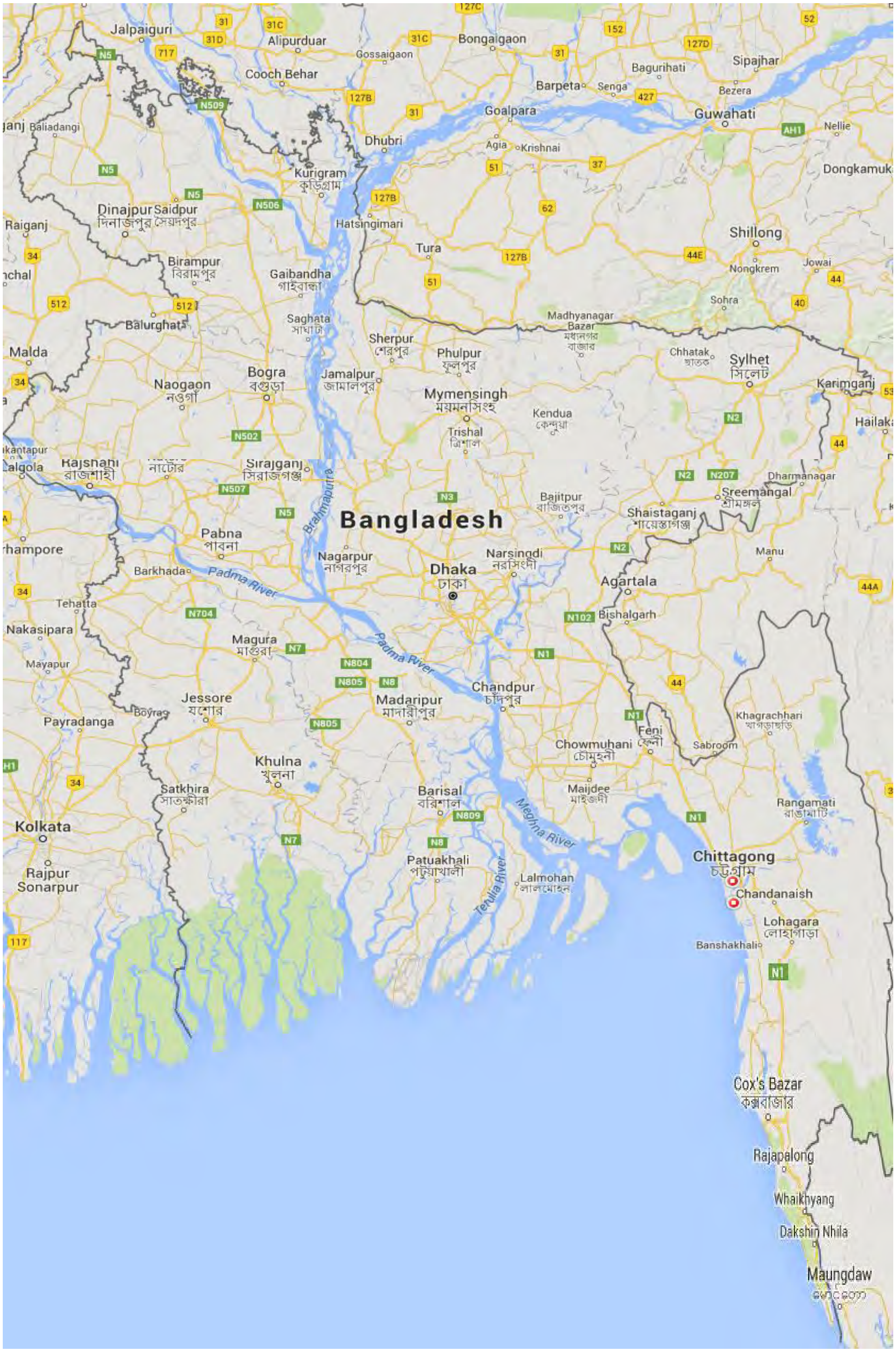
The average monthly, annual and seasonal variation of all the climate data have been computed from the historical daily time series data.

3.5. STUDY AREA

Bangladesh a land of worlds one of the largest deltaic fluvial system experienced a subtropical monsoon climate characterized by wide seasonal variations in rainfall, moderately temperatures, and high humidity has been chosen for the study. Thirty five meteorological stations which nearly cover all part of the country are selected from the six divisions of Bangladesh as follows:

Table 3-3: Project Area

Divisions	**Stations**
Dhaka	Dhaka, Tangail, Mymensingh, Faridpur, Madaripur, Syedpur
Chittagong	Chandpur, Comilla, Chittagong, Coxôsbazar, Feni, Rangamati, Teknaf, Sandwip, Sitakunda, M.court, Ambagan, Kutubdia, Hatiya
Rajshahi	Bogra, Rajshahi, Ishurdi
Khulna	Khulna, Chuadanga, Jessore, Satkhira, Mongla
Barisal	Barisal, Bhola, Potuakhali, Khepupara
Sylhet	Sylhet, Srimangal
Rangpur	Dinajpur, Rangpur


Jalpaiguri
Alipurduar
Bongaigaon
Cooch Behar
Gossaigaon
Bagurihati
Sipajhar
Barpeta
Senga
Bezera
Goalpara
Guwahati
Nellie
Baliadangi
Dhubri
Agia
Krishnai
Kurigram
Dongkamuk
Dinajpur
Saidpur
Raiganj
Hatsingimari
Tura
Shillong
Birampur
Gaibandha
Nongkrem
Jowai
Sohra
Balurghat
Saghata
Madhyanagar Bazar
Sherpur
Phulpur
Chhatak
Sylhet
Malda
Bogra
Jamalpur
Naogaon
Mymensingh
Karimganj
Kendua
Trishal
Hailak
Rajshahi
Sirajganj
Dharmanagar
Bajitpur
Sreemangal
Bangladesh
Shaistaganj
Pabna
Manu
Nagarpur
Narsingdi
Dhaka
Barkhada
Padma River
Agartala
Tehatta
Bishalgarh
Nakasipara
Magura
Padma River
Mayapur
Chandpur
Jessore
Madaripur
Payradanga
Boyra
Khagrachhari
Feni
Chowmuhani
Sabroom
Khulna
Barisal
Satkhira
Maijdee
Rangamati
Kolkata
Meghna River
Patuakhali
Chittagong
Rajpur Sonarpur
Tetulia River
Lalmohan
Chandanaish
Lohagara
Banshakhali
Cox's Bazar
Rajapalong
Whaikhyang
Dakshin Nhila
Maungdaw

CHAPTER 4
RESULTS AND DISCUSSIONS

The study has mainly two different parts: i) Variation of cloud cover and other climatic parameters. ii) Correlation between cloud cover and other climatic parameters. The outcome from the study is described in this chapter.

4.1. SPATIAL AND TEMPORAL VARIATION OF CLIMATIC PARAMETERS

Cloud Cover:

For the analysis of cloud cover, only the data of thirty five locations are available. Appendix B represents the monthly variation of cloud cover different locations of Bangladesh. The average monthly, annual and seasonal (Pre-monsoon, Monsoon, Dry season) spatial variation of cloud cover are shown in Figure in Appendix B.

From analysis it is identified that in Bangladesh higher rate of cloud cover from the month June to August and in July it is maximum. In July about seven eighth portions of the sky are covered by cloud. Minimum cloud cover occurs in the month of December and January. In these two months only one eighth portion of the sky is covered by the cloud. Clouds start to form from the month of February to July and again start to diminish from the month of September to January. The Figure 4-1 represents the monthly variation of cloud cover in Bangladesh which is found out using data 1953 to 2011.

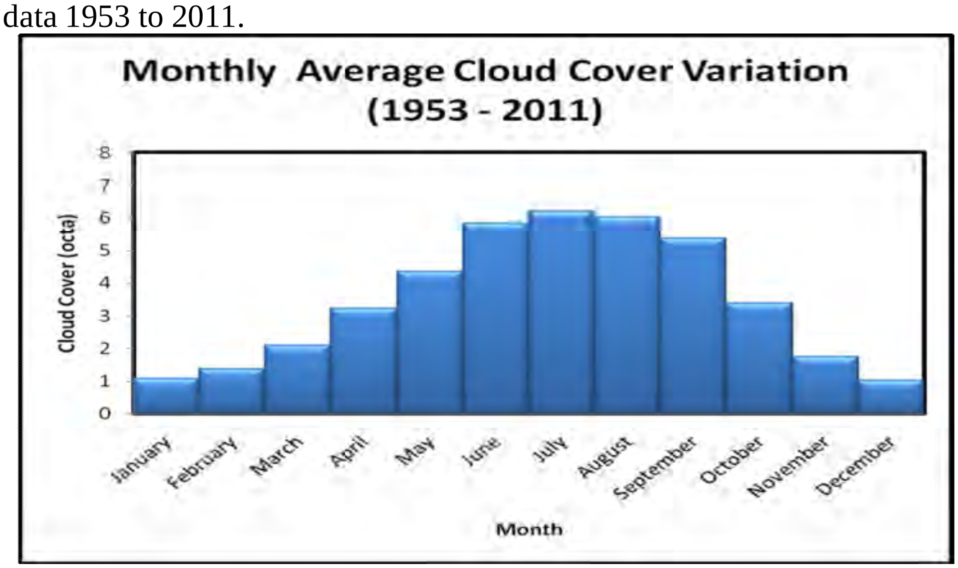


Figure 4-1: Monthly Average Variation of Cloud Cover (data 1953 to 2011) in Bangladesh.

Maximum and Minimum Average cloud cover of a year at different locations of Bangladesh are tabulated in Table 4-1 (data 1953 to 2011)

Table 4-1: Maximum and Minimum Average cloud cover of a year at different locations (data 1953 to 2011)

Station Name	Maximum Average cloud Cover		Minimum Average cloud cover	
	cloud cover (octa)	Month	cloud cover (octa)	Month
Dhaka	6.46	July	1.25	December & January
Tangail	6.04	July	1.08	December
Mymensingh	6.49	July	0.94	December
Faridpur	6.05	July	0.85	December
Madaripur	6.09	July	1.06	December
Srimangal	5.82	July	0.98	December
Sylhet	7.04	July	1.36	December
Bogra	6.19	July	0.96	December
Dinajpur	6.05	July	0.67	December
Ishurdi	6.28	July	1.06	December
Rajshahi	6.06	July	0.95	December
Rangpur	6.07	July	0.98	December
Sydpur	6.05	July	1.2	December
Chuadanga	5.81	July	0.63	December
Jessore	6.2	July	0.87	December
Khulna	6.05	July	0.90	December
Mongla	5.95	July	0.85	January
Satkhira	5.83	July	0.94	December
Barisal	6.51	July	1.01	January
Bhola	6.11	July	1.04	December
Khepupara	6.52	July	0.76	January
Potuakhali	6.45	July	1.06	December
Chandpur	5.53	July	0.82	December
Ambagan	6.53	August	0.92	January
Chittagong	6.38	July	1.06	January
Comilla	6.10	July	0.87	December
Coxôsbazar	6.70	July	0.94	January
Feni	6.71	July	0.97	December
Hatiya	6.27	July	0.92	January
Kutubdia	6.34	July	0.96	January
Maijdicourt	6.38	July	0.7	December
Rangamati	5.93	July	1.5	January
Sandwip	5.92	July	0.69	January
Sitakunda	6	July and August	1	January
Teknaf	6.57	August	0.57	January

Cloud formation is high in monsoon season but in dry season it is low which can be represented by following Figure 4-2 and 4-3:

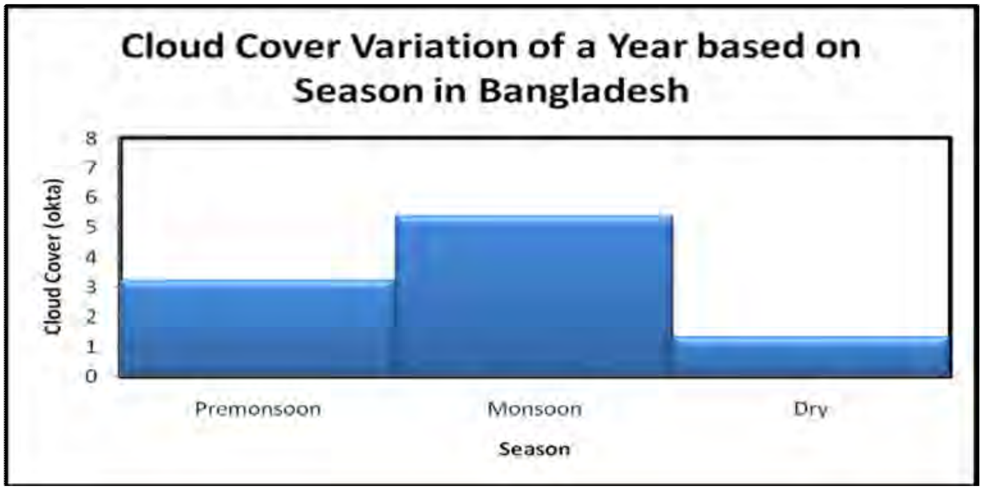


Figure 4-2: Cloud Cover Variation of a Year based on Season in Bangladesh

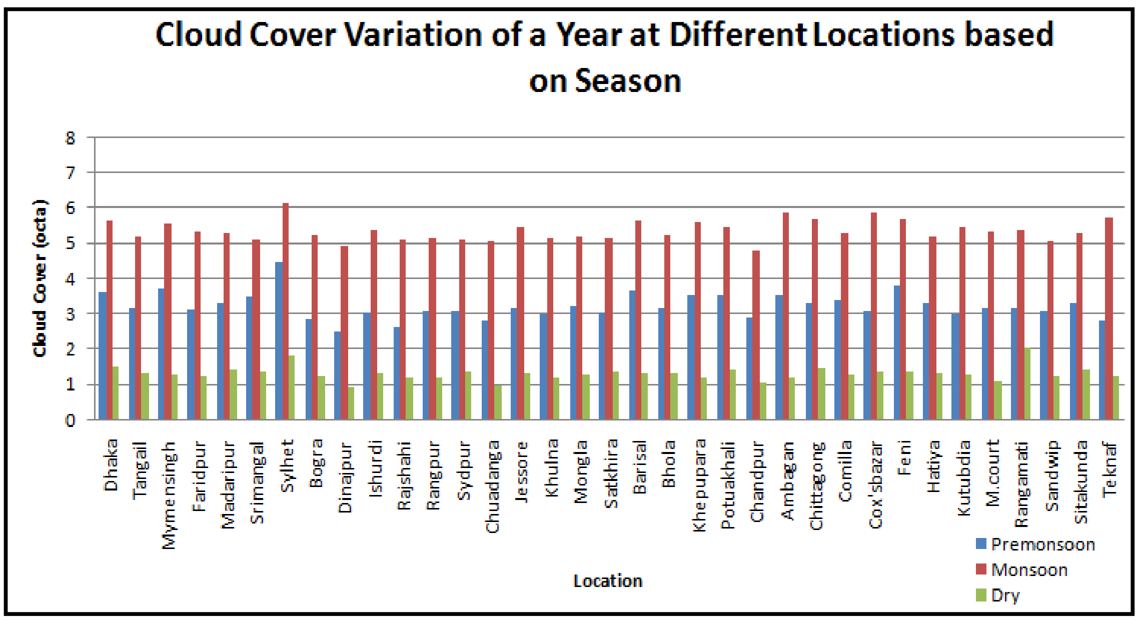


Figure 4-3: Cloud Cover Variation of a year in different locations based on Season

Maximum cloud cover occurs in Sylhet. In this region, most of the time, the whole sky is covered by the cloud in the month of July. And seven eighth portions of the sky are covered by cloud during June and August. Again, in January and December, two eighth portions of the sky are covered by cloud in this region. But Dinajpur which is another district of Bangladesh, minimum cloud cover occurs in the sky of it than that of others. In this region, maximum cloud cover occurs in the month of July. In this time only six eighth portions of the sky are covered by cloud. But in December about one eighth portions of the sky is covered by cloud.

From Figure we can see that cloud cover of different locations in Bangladesh is not same. Geological position, humidity variation, plant density, wind speed variation, temperature changes etc. are important parameters to form cloud and causes for cloud cover variation. Shylet, Chittagong, Rangamati, some portions of Mymensingh etc. are the hilly region. On the other hand, Teknaf, Noakhali, Feni, Barisal, Khepupara, Khulna etc. are the coastal regions. Again, Dhaka, Faridpur, Pabna, Sirajgong etc. are the plain land regions. Chittagong, Rangamati, Shylet, Khulna, Tangail, Satkhira, Barisal Gazipur, Noakhali etc. distircts have green forest and Rajshahi, Bogra, Rangpur, Pabna etc. are the driest regions. Besides, we have scattered innumerable large and small scale rivers all over the country. For these reasons, cloud cover in the sky of all districts in our country is not same.

Figure 4-4, Figure 4-5 and Figure 4-6 represents annual variation of average cloud cover at different locations in Bangladesh, monthly average cloud cover variation of Syhlet and monthly average cloud cover variation of Dinajpur respectively. As cloud cover in the sky is more in Sylhet and is less in Dinajpur than that of other Districts, so to know the monthly average cloud cover variation scenario all the year round of these two districts which will help us to make relation with other parameters, their monthly average cloud cover variation pattern has been shown here.

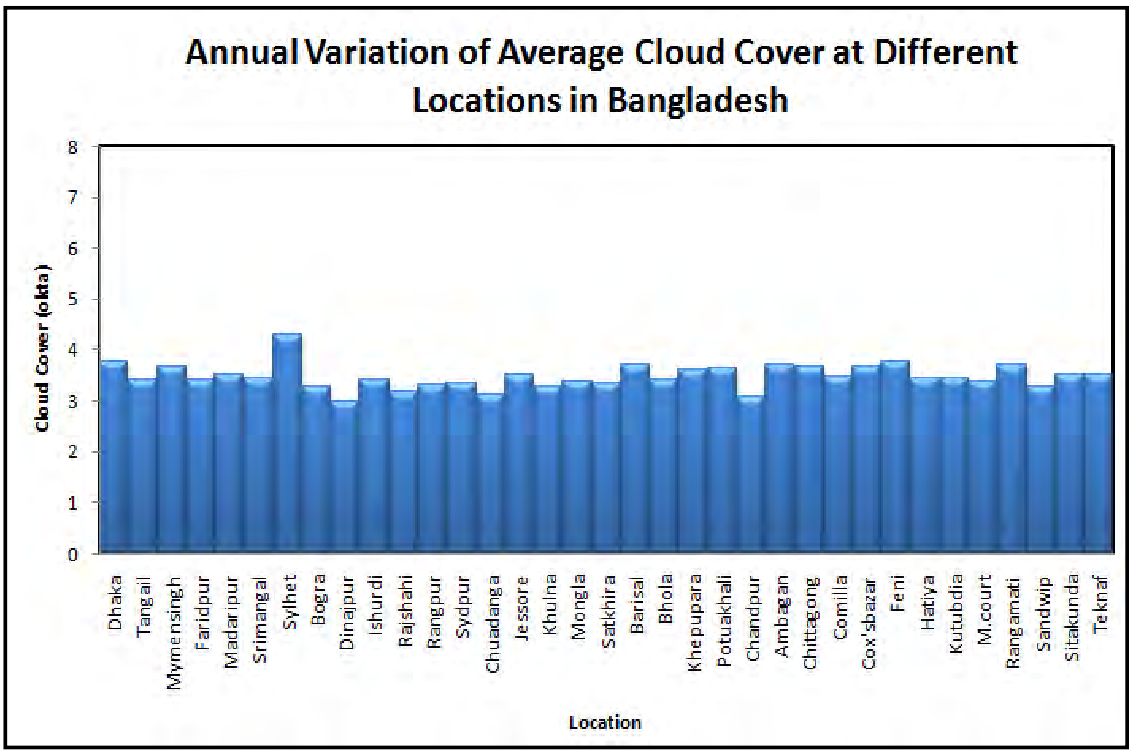


Figure 4-4: Annual Variation of Average Cloud Cover at Different Locations in Bangladesh (Using data 1953 ï 2011)

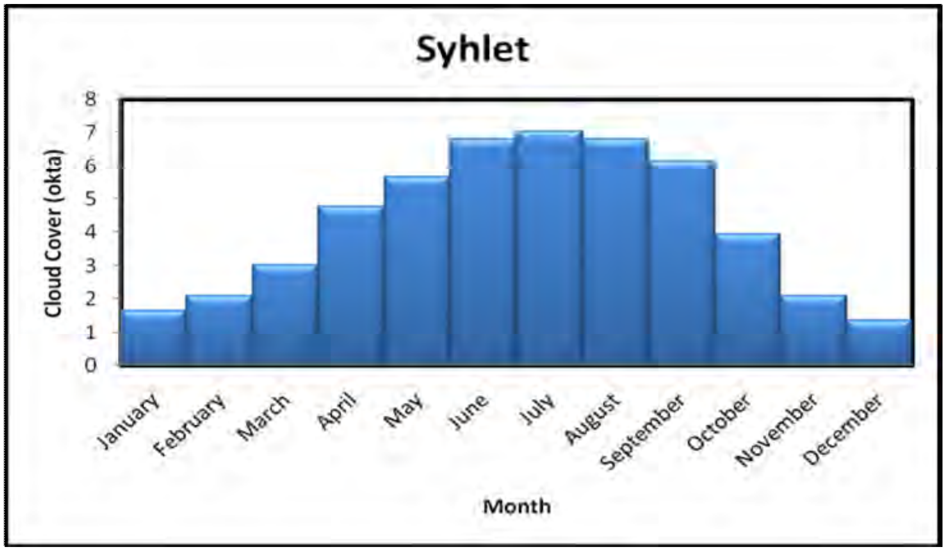


Figure 4-5: Monthly Average Cloud Cover Variation of Syhlet

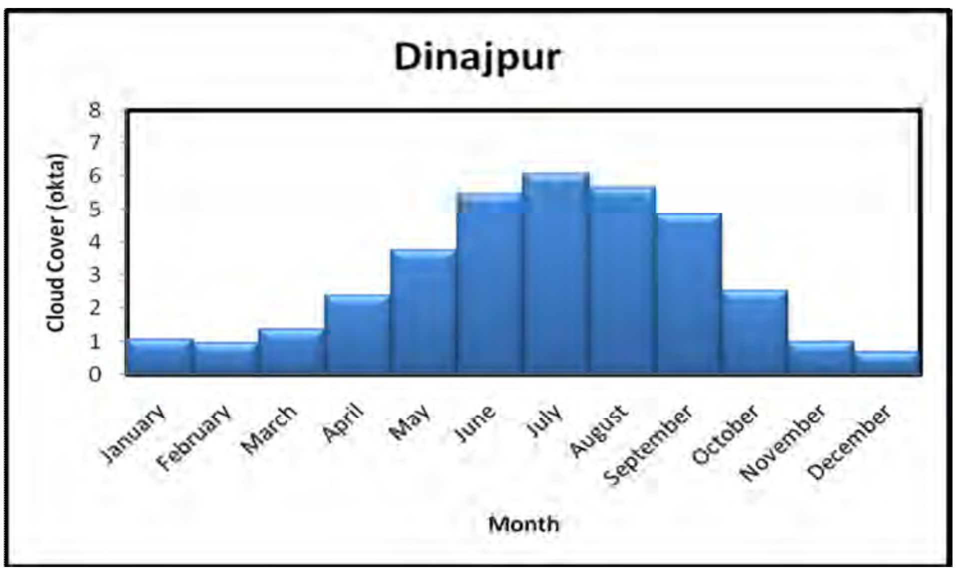


Figure 4-6: Monthly Average Cloud Cover Variation of Dinajpur

The entire monthly, seasonally and yearly variation of cloud cover of different locations of Bangladesh are tabulated form in Table A1 of Appendix A.

Temperature

Three sets of temperature data for 35 locations of Bangladesh have been analyzed. These are daily average temperature, monthly average maximum temperature and monthly average minimum temperature. Appendix C represents the monthly variation of average temperature in different locations of Bangladesh. The average annual and seasonal (Pre-Monsoon, Monsoon, Dry season) variation of temperature are shown in Appendix C.

In Bangladesh maximum temperature observed in April or May. The variation of average temperature is little from April to September. Temperature begins to decrease from the month of October and falls at lowest in January. The average monthly temperature varies from 9ęc (Srimangal, January) to 37ęc (Chuadanga, April). Rajshahi, Jessore, Satkhira, Dinajpur, Ishurdi, Syedpur, Rangpur, and Srimangal are the area where the variation of maximum and minimum temperature is very high. These locations can be identified as extreme temperature area. The range between maximum and minimum temperature is comparatively lower in Kutubdia, Sandwip, Hatiya, Teknaf, Chittagong and Coxôsbazar. Figure 4-7, Figure 4-8, Figure 4-9 and Figure 4-10 shows Monthly Average Maximum Temperature Variation, Monthly Average Minimum Temperature Variation, Annual Variation of Average Maximum Temperature at Different Locations and Figure 4-10: Annual Variation of Average Minimum Temperature at Different Locations of Bangladesh respectively.

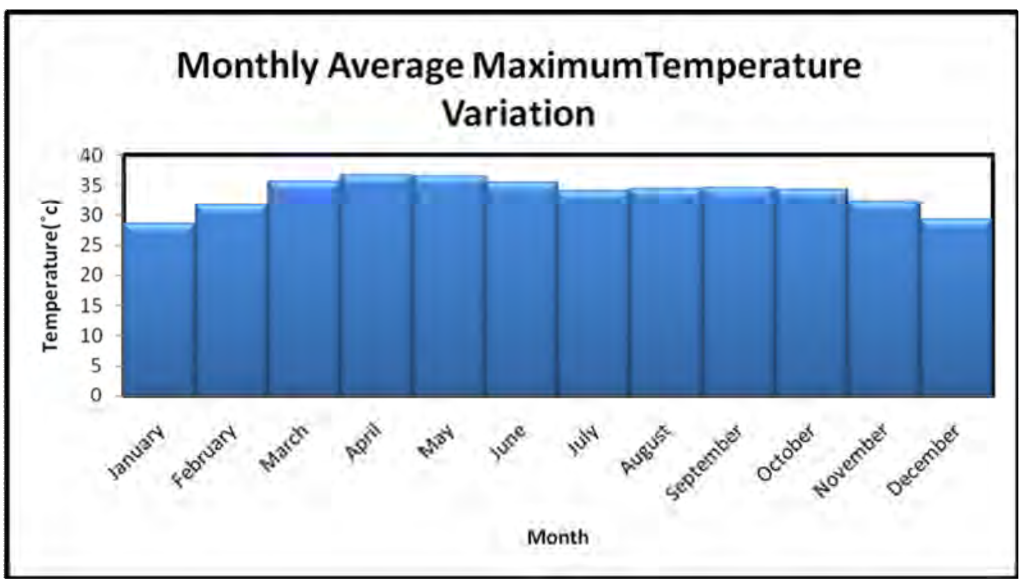


Figure 4-7: Monthly Average Maximum Temperature Variation of Bangladesh

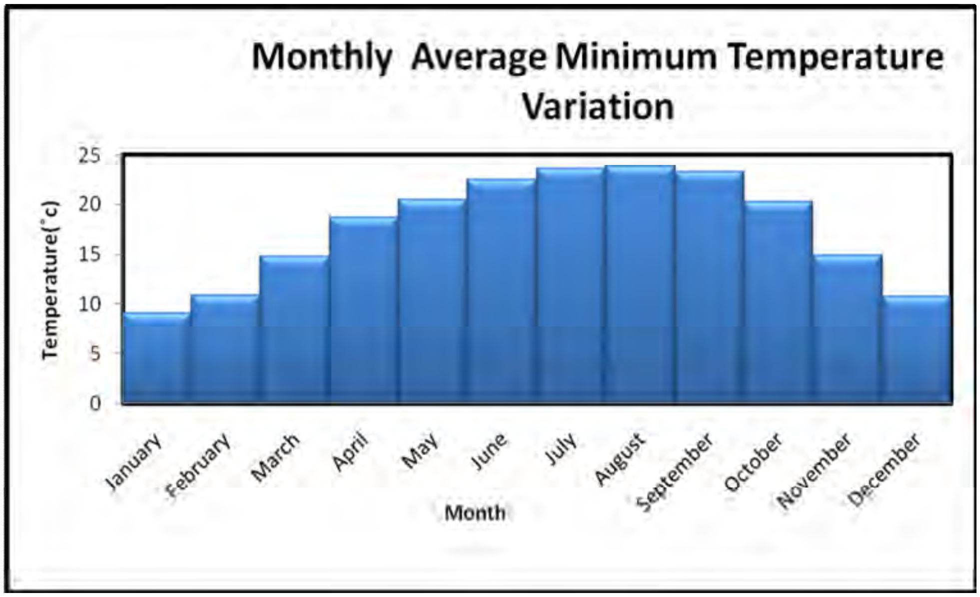


Figure 4-8: Monthly Average Minimum Temperature Variation of Bangladesh

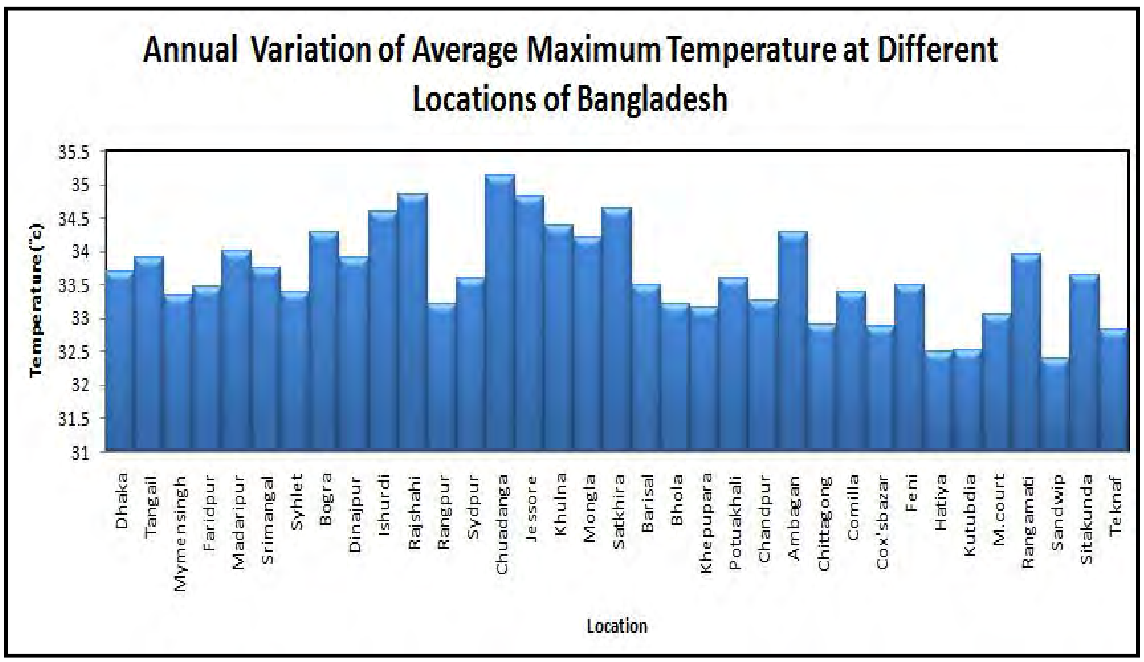


Figure 4-9: Annual Variation of Average Maximum Temperature at Different Locations of Bangladesh

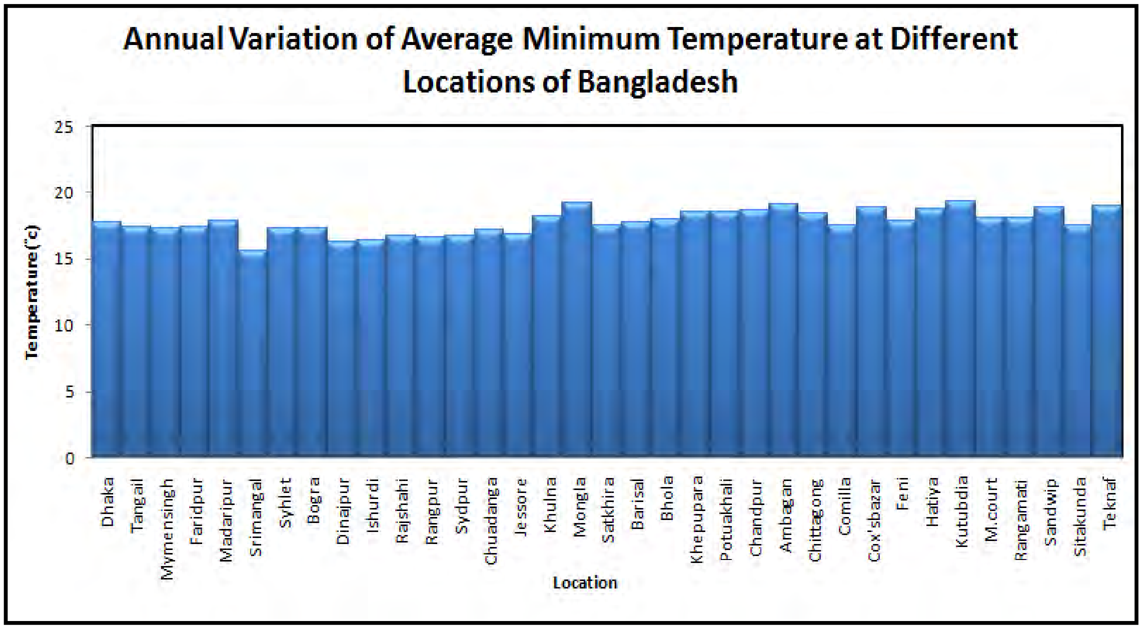


Figure 4-10: Annual Variation of Average Minimum Temperature at Different Locations of Bangladesh

Maximum and Minimum temperature at different locations of Bangladesh are tabulated in Table 4-2.

Table 4-2: Maximum and Minimum average temperature at different locations of Bangladesh

Station Name	Maximum Temperature		Minimum Temperature		Temperature Range
	Temperature (ºc)	Month	Temperature (ºc)	Month	
Dhaka	33.69	April	17.77	January	15.92
Tangail	33.90	April	17.40	January	16.49
Mymensingh	33.34	April	17.26	January	16.07
Faridpur	33.46	April	17.36	January	16.09
Madaripur	33.99	April	17.89	January	16.10
Srimangal	33.75	April	15.58	January	18.17
Sylhet	33.37	May	17.25	January	16.12
Bogra	34.27	April	17.26	January	17.00
Dinajpur	33.90	April	16.21	January	17.68

Ishurdi	34.59	April	16.38	January	18.20
Rajshahi	34.85	April	16.76	January	18.09
Rangpur	33.21	April	16.60	January	16.61
Sydpur	33.58	May	16.73	January	16.84
Chuadanga	35.13	May	17.13	January	18.00
Jessore	34.82	April	16.87	January	17.94
Khulna	34.39	April	18.18	January	16.20
Mongla	34.20	May	19.13	January	15.06
Satkhira	34.63	May	17.46	January	17.17
Barisal	33.49	April	17.74	January	15.75
Bhola	33.21	May	17.99	January	15.22
Khepupara	33.16	April	18.51	January	14.65
Potuakhali	33.59	April	18.47	January	15.11
Chandpur	33.26	May	18.62	January	14.64
Ambagan	34.27	April	19.03	January	15.23
Chittagong	32.89	May	18.43	January	14.46
Comilla	33.38	April	17.48	January	15.90
Coxôsbazar	32.87	May	18.89	January	13.97
Feni	33.49	May	17.83	January	15.66
Hatiya	32.48	May	18.69	January	13.79
Kutubdia	32.52	May	19.28	January	13.23
Maijdicourt	33.05	May	18.10	January	14.95
Rangamati	33.94	April	18.06	January	15.88
Sandwip	32.38	May	18.82	January	13.56
Sitakunda	33.65	May	17.51	January	16.13
Teknaf	32.82	May	18.98	January	13.84

In case of seasonal variation maximum average temperature occurs in monsoon seasons (June to October) where average temperature varies from 27.30ęc to 28.65ęc and minimum average temperature occurs in dry season (November to February) where average temperature varies from 18.349ęc to 23.23ęc. But few exceptions are found in Satkhira, Coxôsbazar, Teknaf and Mongla where maximum average temperature observed in pre-monsoon season. Figure 4-11 and 4-12 represent the seasonal variation of temperature at different locations of Bangladesh.

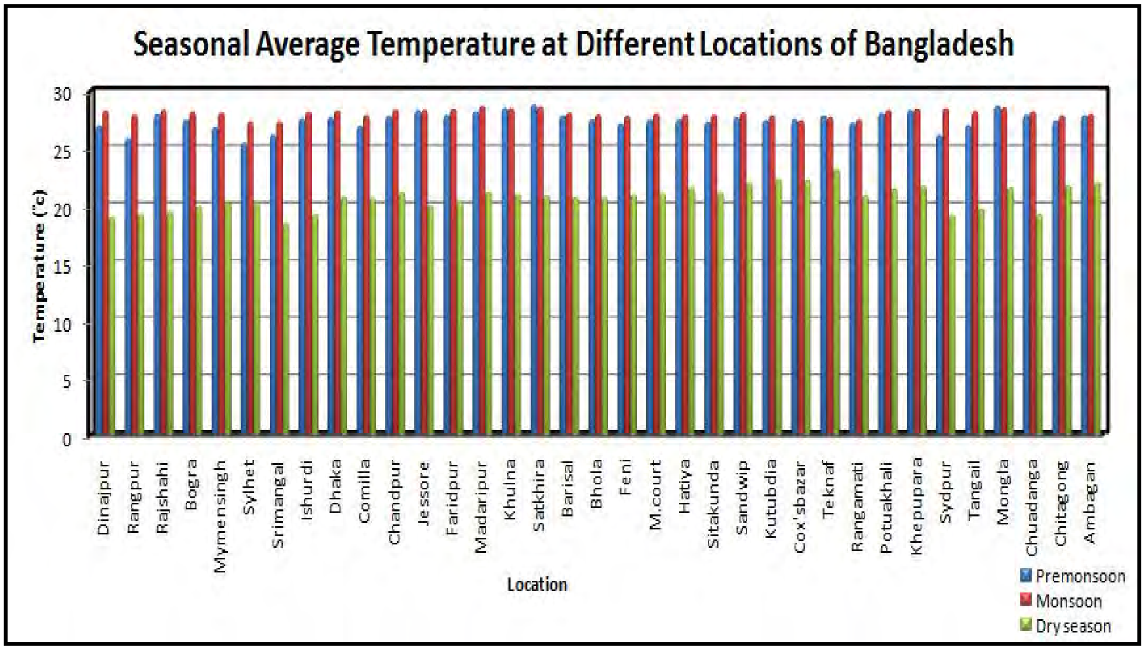


Figure 4-11: Seasonal Variation of Temperature at Different Locations of Bangladesh

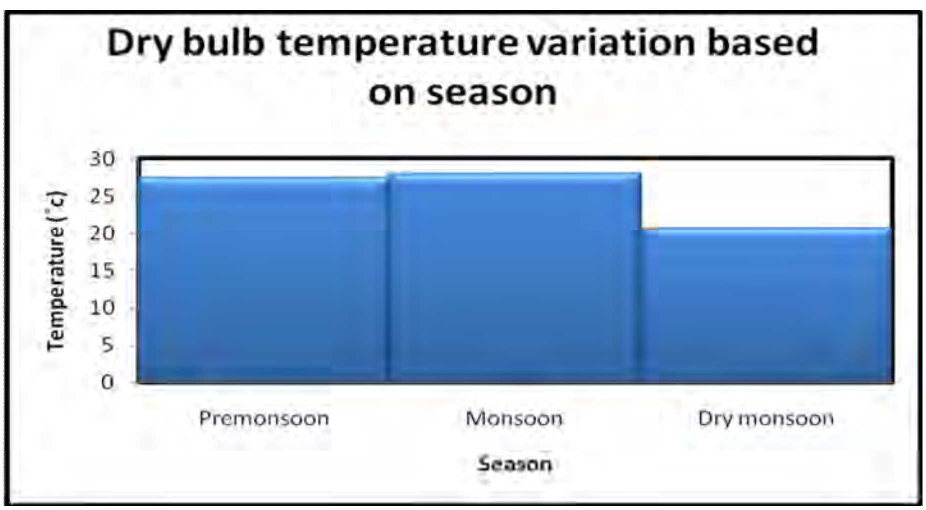


Figure: 4-12: Seasonal Average Variation of Temperature in Bangladesh

Again the yearly variation of average minimum and maximum temperature in different locations is in between 15.58ºc to 35.13ºc. The yearly average maximum and minimum temperature at different locations of Bangladesh are represented in Figure 4-13.

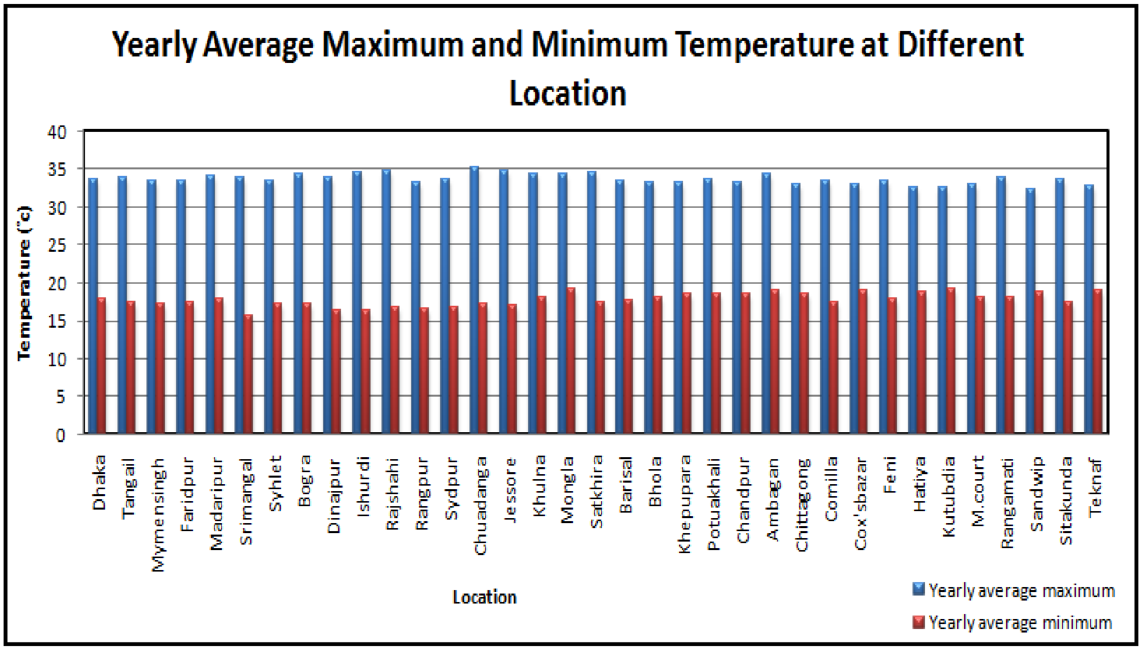


Figure 4-13: Yearly Average Maximum and Minimum Temperature at Different Locations

Relative Humidity

Relative humidity data of 35 stations of Bangladesh are available. Appendix D represents the monthly variation of relative humidity at different locations of Bangladesh. The average seasonal (Pre-monsoon, Monsoon, Dry Period) and average annual relative humidity are shown in figure in Appendix D.

In Bangladesh the average annual humidity is 79.52%. In most of the locations maximum amount of humidity occurs in the month of July. But in few locations it is observed as high rate in the month of June, July, August, September and October. Again minimum amount of humidity occurs in March and in some locations it is observed in January and February. The range of relative humidity varies from 58.56% (Dinajpur, March) to 89.9% (Bhola, Potuakhali and Sandwip, July). The monthly variation of relative humidity of Bangladesh and the monthly variation of relative humidity at Dinajpur are represented in Figure 4-14 and 4-15 respectively.

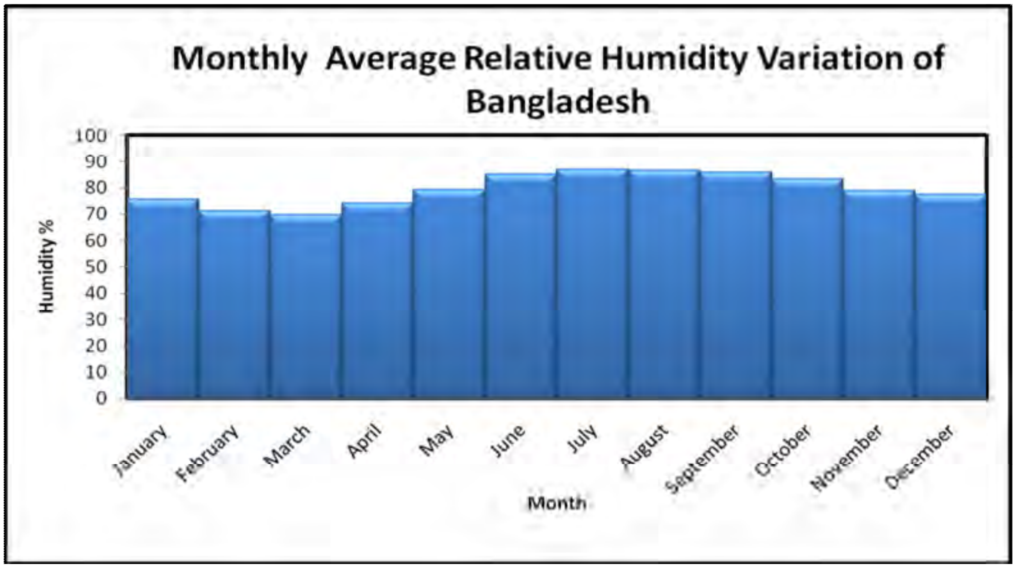


Figure 4-14: Monthly Average Relative Humidity Variation of Bangladesh

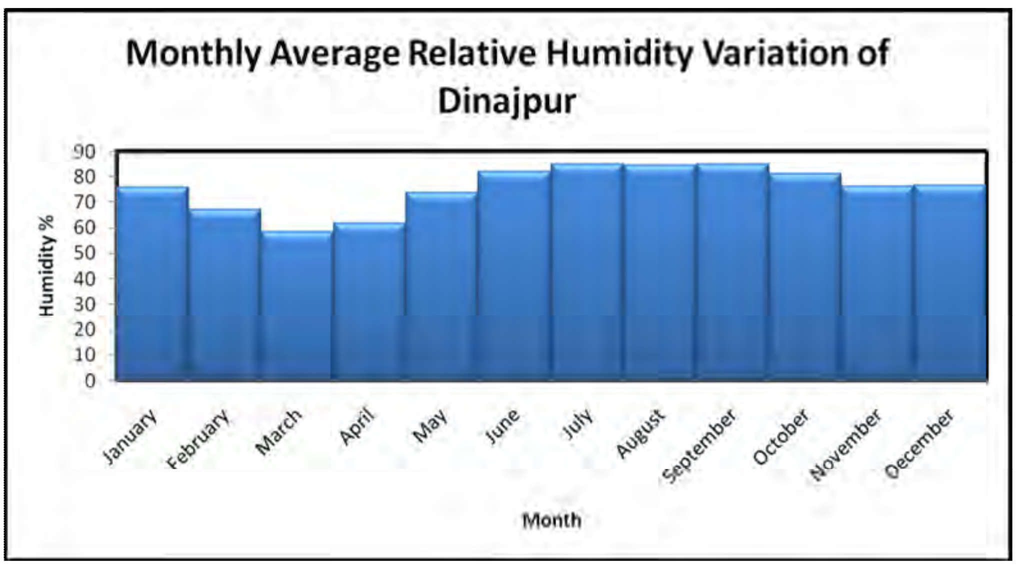


Figure 4-15: Monthly Average Relative Humidity Variation of Dinajpur

In monsoon season humidity is high due to rainfall. The average seasonal variation of relative humidity at different locations of Bangladesh is represented in Figure 4-16 and 4-17.

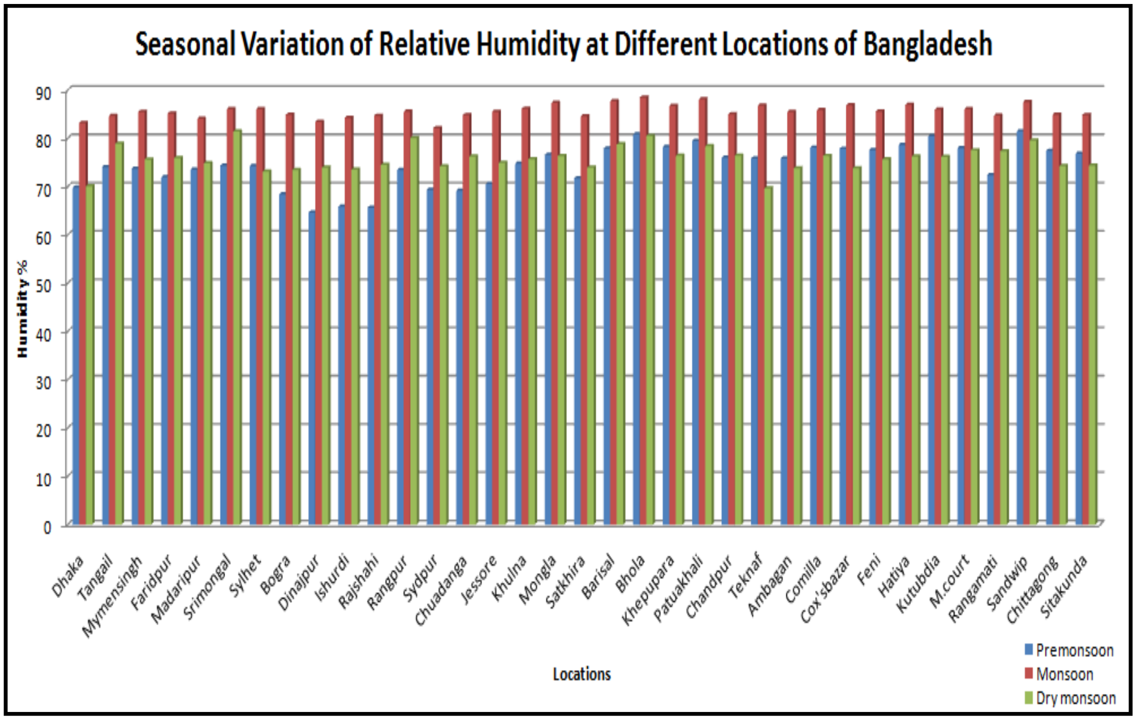


Figure 4-16: Seasonal Variation of Relative Humidity at Different Locations of Bangladesh

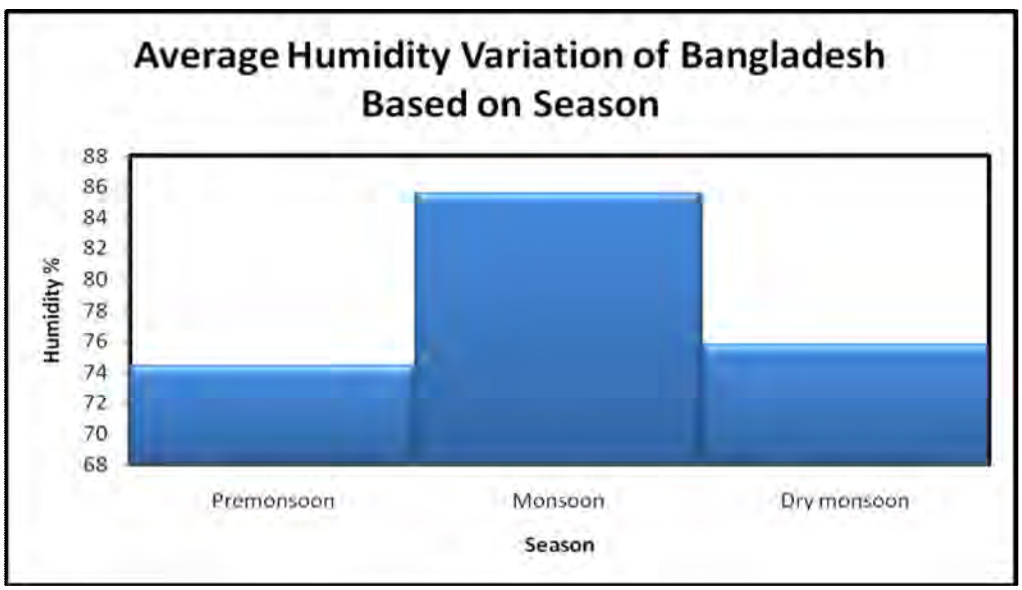


Figure 4-17: Average Relative Humidity Variation of Bangladesh based on Season

The yearly average relative humidity variation at different locations of Bangladesh is represented in Figure 4-18.

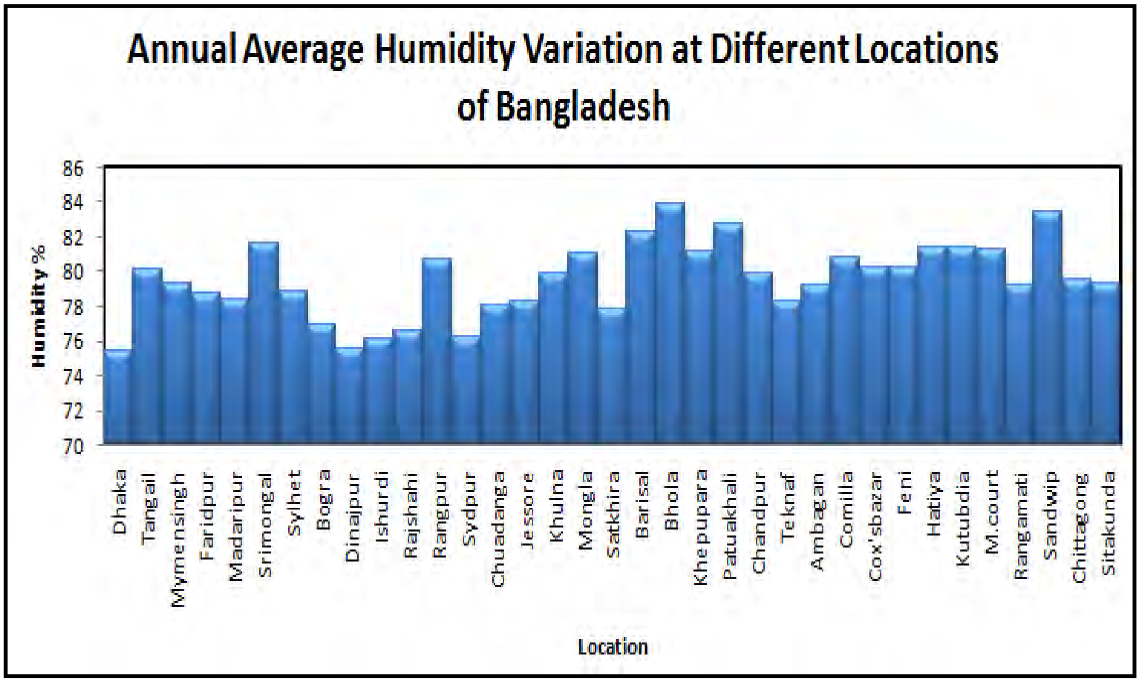


Figure 4-18: Annual Average Relative Humidity Variation at Different Locations of Bangladesh

Rainfall

Rainfall data of 35 stations of Bangladesh are available. Appendix E represents the monthly variation of variation rainfall rate (mm/day) at different locations Bangladesh. The average seasonal (Pre-monsoon, Monsoon, Dry Period) and average annual rainfall rate are shown in Figure in Appendix E.

From the analysis it is found that the average annual total rainfall of the country is 2407 mm. Heavy rate of rainfall occurs in the month of June, July and August at the time of full monsoon and in July the rate is maximum. Minimum rate of rainfall occurs in the month of December and January. Basically, rainfall rate begins to decrease from the month of August to January and again starts to increase from the month of February to July. Figure 4-19 represents the monthly variation of total rainfall of Bangladesh.

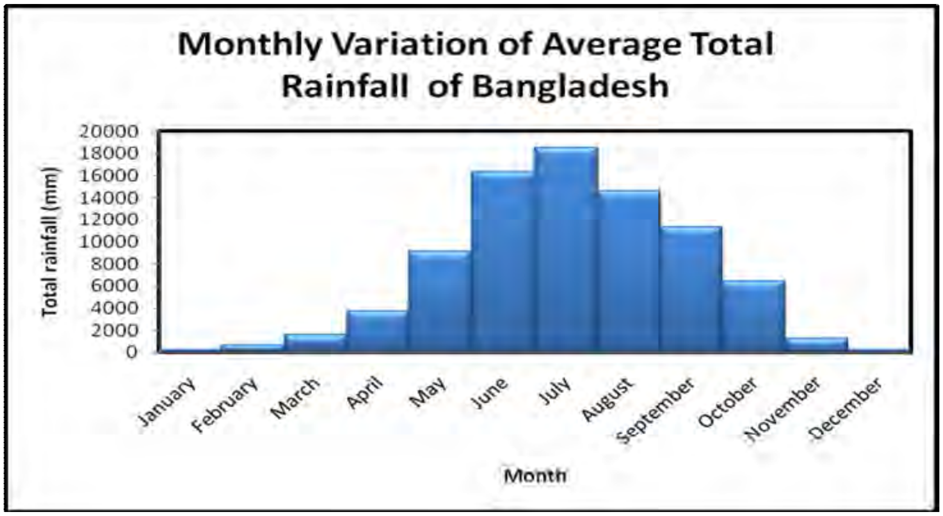


Figure 4-19: Monthly Variation of Average Total Rainfall of Bangladesh (Data 1953 - 1911)

Rainfall mainly occurs in monsoon season and average rainfall varies from 1208.99 mm to 3604.64 mm. Maximum rainfall occurs in monsoon season in Teknaf. It is also found that heavy rainfall occurs in Coxôsbazar, Sandwip & Sylhet during the monsoon season. In pre-monsoon period average rainfall is 413.771 mm but in sylhet it exceeds 1000 mm. In dry period there is very little amount of rainfall (average 70.98 mm). The average annual total rainfall of the country is 2407 mm. The seasonal average rainfall variation at different locations of Bangladesh is represented in Figure 4-17 and 4-18.

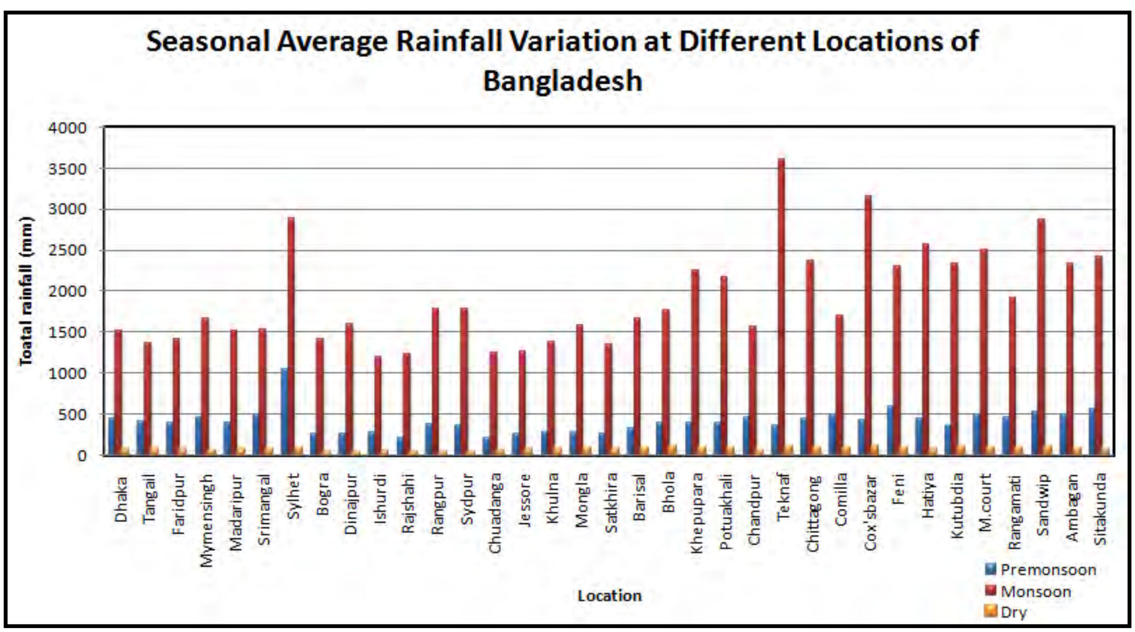


Figure 4-20: Seasonal Average Rainfall Variation at Different Locations

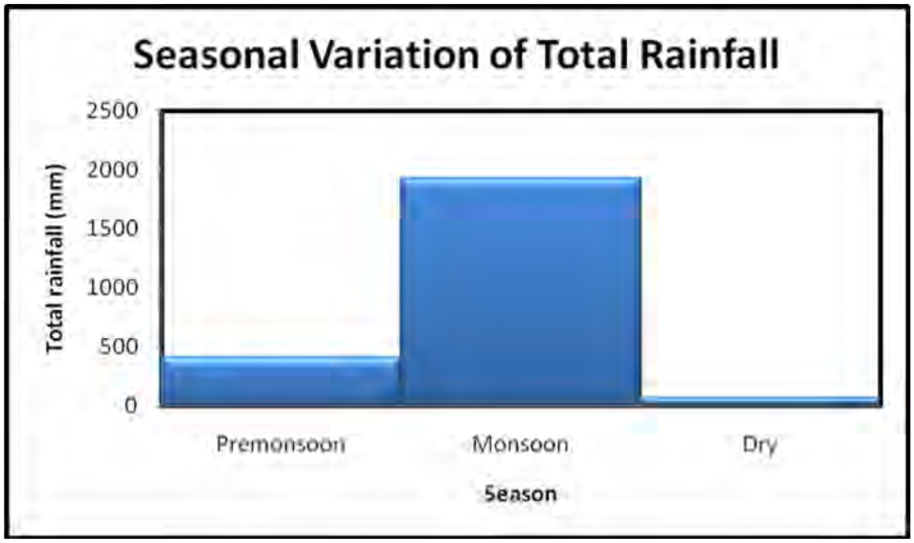


Figure 4-21: Seasonal Variation of Total Rainfall of Bangladesh

Average annual maximum rainfall occurs in Teknaf (4065.241 mm) and Sylhet and minimum rainfall occurs in Rajshahi (1484.92 mm). So Rajshahi is the driest part of the country. The annual variation total rainfall at different location of Bangladesh is represented in Figure 4-22.

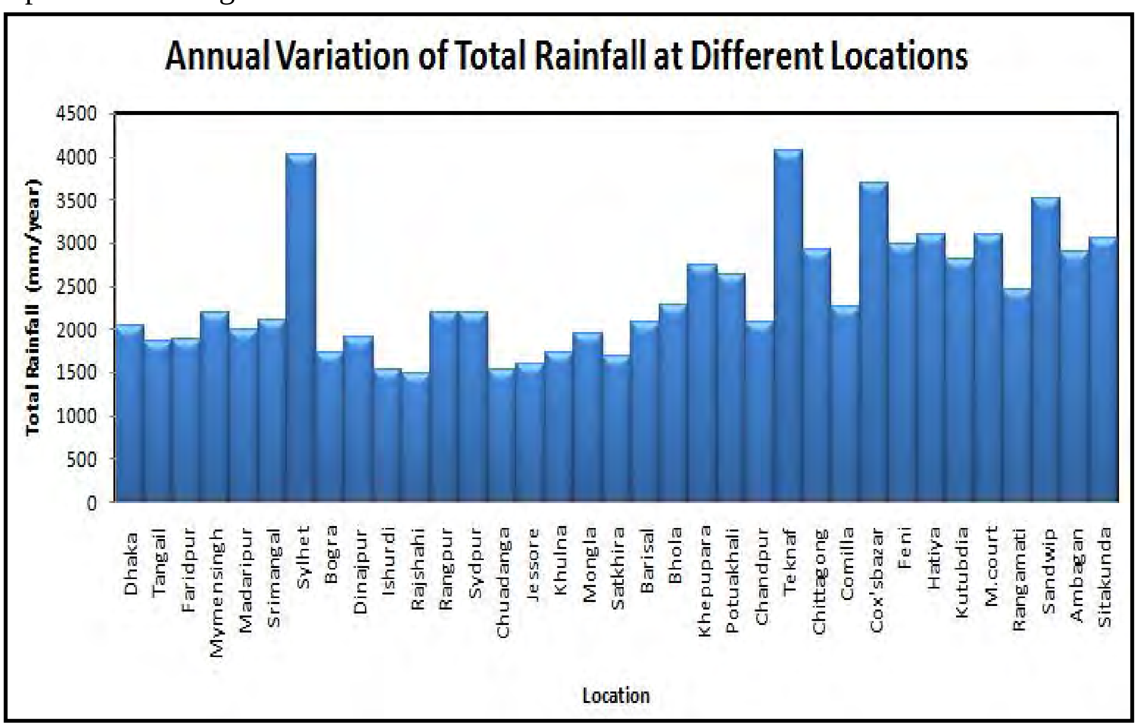


Figure 4-22: Annual Variation of Average Total Rainfall at Different Location of Bangladesh

4.2. CO-RELATION BETWEEN CLOUD COVER AND OTHER CLIMATIC PARAMETERS

The correlation coefficient (r) between cloud cover and other climatic parameters are given in Table 4-3.

Table 4-3: Correlation between Cloud Cover and Other Climatic Parameters

Station Name	r		
	T	RH	RF
Dhaka	0.86	0.83	0.98
Tangail	0.87	0.62	0.98
Mymensingh	0.89	0.74	0.97
Faridpur	0.85	0.74	0.98
Madaripur	0.84	0.82	0.98
Srimangal	0.90	0.37	0.98
Sylhet	0.92	0.81	0.97
Bogra	0.83	0.75	0.99
Dinajpur	0.82	0.63	0.98
Ishurdi	0.83	0.69	0.98
Rajshahi	0.79	0.69	0.98
Rangpur	0.89	0.56	0.97
Sydpur	0.86	0.71	0.98
Chuadanga	0.83	0.64	0.94
Jessore	0.83	0.76	0.98
Khulna	0.82	0.86	0.98
Mongla	0.84	0.87	0.96
Satkhira	0.82	0.82	0.98

Barisal	0.86	0.82	0.96
Bhola	0.83	0.87	0.98
Khepupara	0.86	0.90	0.94
Potuakhali	0.85	0.88	0.96
Chandpur	0.85	0.85	0.98
Ambagan	0.83	0.84	0.94
Chittagong	0.85	0.95	0.92
Comilla	0.89	0.87	0.97
Cox'sbazar	0.76	0.98	0.93
Feni	0.87	0.86	0.95
Hatiya	0.82	0.90	0.96
Kutubdia	0.80	0.97	0.94
M.court	0.84	0.87	0.96
Rangamati	0.79	0.76	0.95
Sandwip	0.84	0.94	0.95
Sitakunda	0.85	0.89	0.97
Teknaf	0.73	0.97	0.93
Average	0.84	0.80	0.96

- T = Temperature (ęc), RH = Relative Humidity (%), RF = Rainfall (mm)

The correlation coefficient (r) between cloud cover with other climatic parameters are divided in to three categories. These are Small Correlation, Medium Correlation and Large Correlation and the range of value of r are given in the Table 4-4 below:

Table 4-4: Size of Correlation

Correlation	Negative	Positive
Small	-0.3 to -0.1	0.1 to 0.3
Medium	-0.5 to -0.3	0.3 to 0.5
Large	-1.0 to -0.5	0.5 to 1.0

From Table 4-4 it is found that the correlation between cloud cover with humidity, temperature and rainfall is positive and the value of r is large in maximum locations. That is if the value of humidity, temperature and rainfall are increased, cloud cover will also be increased. The figures 4-20, 4-21 and 4-22 represent the correlation between cloud cover with Temperature, Relative Humidity and rainfall at Syhlet.

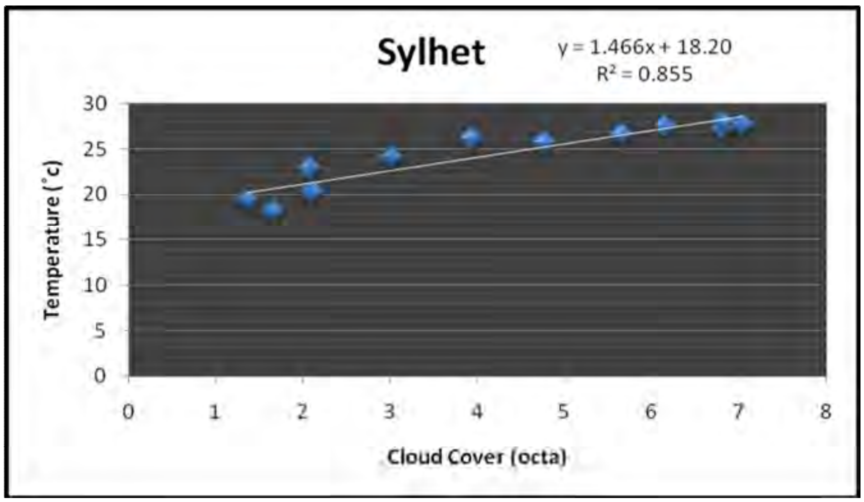


Figure 4-23: Correlation between Cloud Cover with Temperature

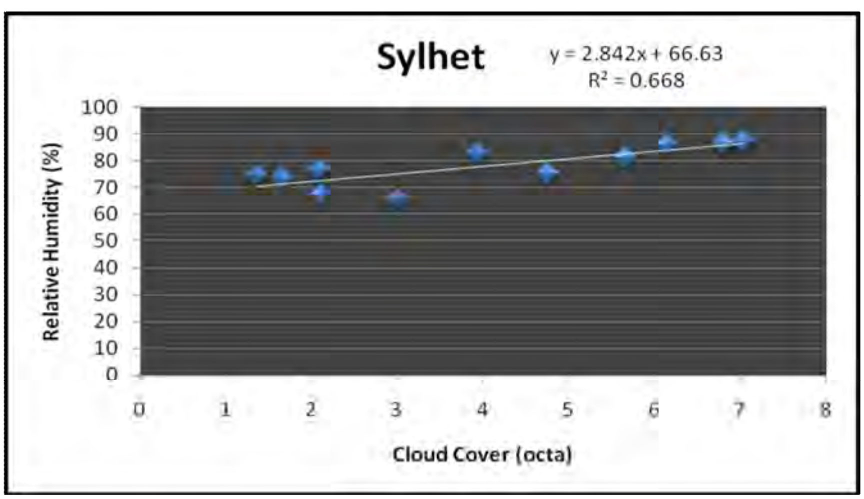


Figure 4-24: Correlation between Cloud Cover with Relative Humidity

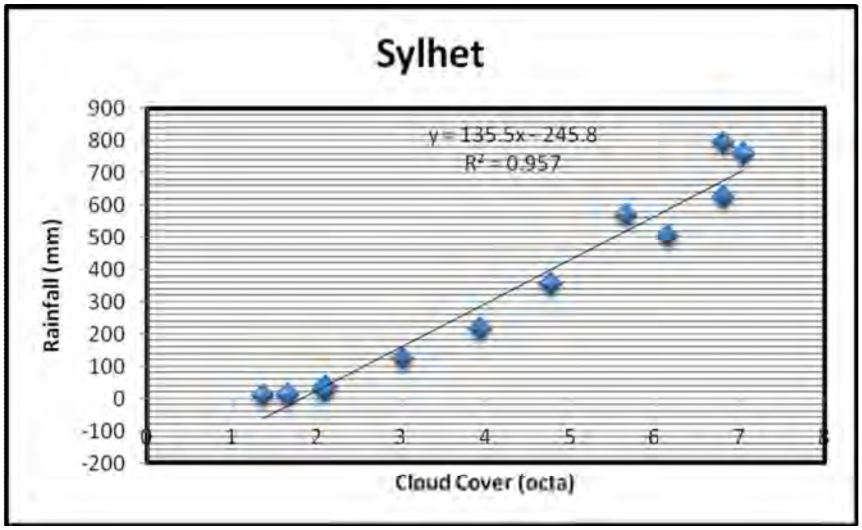


Figure 4-25: Correlation between Cloud Cover with Rainfall

Again the value of r for humidity in Srimangal is positive and medium.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1. GENERAL

This study is based on the spatial and temporal variation of cloud cover related climatic parameters such as temperature, relative humidity and rainfall. Arc- View 3.2 GIS tool has been used for creating maps of spatial variation of different climatic parameters for different seasons. The correlation between cloud cover with the other climatic parameters is also determined by means of Pearson Product Moment Correlation Coefficient.

5.2. CONCLUSIONS

This Study supports the following conclusions:

1) In Bangladesh large amount of cloud coverage occurs from the month of June to September and in July it is maximum. In July, about seven eighth portions of the sky are covered by cloud. Small amount of cloud coverage occurs from the month of November to May and minimum in the months of December and January. In the month of January and December, only one eighth portions of the sky are covered by the cloud. Clouds begin to form from the month of February and in July the cloud formation is in large extent. Again cloud formation starts to diminish from the month of September and in December and January the formation is in little extent. In Monsoon season cloud formation is high but it is low in Dry season in most of the districts of Bangladesh. Annual variation trend at different location represents that maximum cloud coverage occurs in Sylhet and minimum in Dinajpur.

2) In Bangladesh temperature is maximum in April or May and is minimum in January. The variation of temperature is little from April to September. Temperature begins to decrease from the month of October and falls at lowest in January and again starts to increase from the month of February. The average monthly temperature varies from 9ęc to 37ęc. Maximum average temperature occurs in monsoon seasons (June to October) where average temperature varies from 27.30ęc to 28.65ęc and minimum average temperature occurs in dry season (November to February) where average temperature varies from 18.49ęc to 23.23ęc.The analysis shows that the highest temperature district in Bangladesh is Chuadanga and then Rajshahi, Jessore. Again the lowest temperature district in Bangladesh is Srimangal and then Dinajpur.

3) In Bangladesh large percentage humidity occurs in Bhola, Sandwip, Patuakhali, Barisal and Srimangal districts. The average annual humidity in Bangladesh is 79.52%.In most of the location heavy amount of humidity occurs from the month of June to October and in July it is maximum but in March it is minimum. The range of relative humidity varies from 58056% to 89.9%. The lowest rate of humidity occurs in Dinajpur in the month of March and the highest rate of humidity occurs in Bhola, Potuakhali and Sandwip in the month of July.

4) The average annual total rainfall of Bangladesh is about 2394.28 mm. Heavy rate of rainfall occurs in the months of June, July and August at the time of full monsoon and in July the rate is maximum. Minimum rate of rainfall occurs in the months December and January. Basically, rainfall rate begins to decrease from the month of August to January and again starts to increase from the month of February to July. Rainfall mainly occurs in monsoon season and average rainfall varies from 1208.99 mm to 3604.64 mm. In Pre-monsoon period average rainfall is 413.771 mm but in sylhet it exceeds 1000 mm. In Dry period in fact there very little amount of rainfall i.e. 70.98 mm. Average annual maximum rainfall occurs in Teknaf (4065.241 mm) and Sylhet (4016.286 mm) and minimum rainfall occurs in Rajshahi (1484.92 mm).

5) The correlation coefficient (r) between cloud cover with temperature, humidity and rainfall is large and positive. It means that cloud cover rate is increased with the increasing value of temperature and humidity. It also means rainfall rate and temperature increase with the increasing of cloud cover in the sky.

6) The value of ớrô between cloud cover and humidity in Srimangal is small and positive but in case of rainfall in Srimangal it is large and positive.

5.3. RECOMMENDATIONS

The recommendation for future investigations and study can be as follows:

1. The 3 hourly cloud cover data for the study can be used in model to determine the rate of cloud cover according to time based temperature i.e. at Midnight, in the Morning, at Noon, in the Afternoon, at Evening, at Night etc.

2. Statistical relationship can be determined among cloud cover and other climatic parameters such as evaporation, wind speed and solar radiation etc. by using collected climatic data.

3. The global warming and global dimming of different parts of Bangladesh can be identified by using cloud cover, temperature and solar radiation data etc.

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APPENDIX A
TEMPORAL VARIATION OF CLIMATIC PARAMETERS

Table A1: Average Monthly, Annual and Seasonal Variation of Cloud Cover (okta) at Different Locations of Bangladesh

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
Dhaka	1.25	1.64	2.39	3.58	4.82	6.07	6.46	6.26	5.73	3.69	1.94	1.25	3.76	3.60	5.64	1.52
Tangail	1.2	1.36	2.04	3.16	4.36	5.6	6.04	5.8	5.2	3.36	1.6	1.08	3.4	3.18	5.2	1.31
Mymensingh	1.05	1.57	2.24	3.78	5.05	6.05	6.49	6.22	5.64	3.40	1.49	.94	3.66	3.69	5.56	1.26
Faridpur	1.1	1.31	2.11	3.06	4.21	5.75	6.05	5.95	5.38	3.4	1.68	.85	3.40	3.13	5.30	1.23
Madaripur	1.18	1.51	2.21	3.30	4.36	5.66	6.09	5.96	5.33	3.42	1.84	1.06	3.49	3.29	5.29	1.40
Srimangal	1.24	1.58	2.38	3.52	4.54	5.58	5.82	5.7	5.06	3.26	1.66	.98	3.44	3.48	5.08	1.36
Sylhet	1.65	2.10	3.02	4.76	5.65	6.8	7.04	6.80	6.14	3.93	2.08	1.36	4.28	4.48	6.14	1.80
Bogura	1.14	1.23	1.69	2.76	4.14	5.73	6.19	5.83	5.19	3.10	1.51	.96	3.29	2.86	5.21	1.21
Dinajpur	1.05	.96	1.34	2.38	3.75	5.44	6.05	5.65	4.84	2.51	.98	.67	2.97	2.49	4.90	.91
Ishurdi	1.13	1.33	1.84	3	4.22	5.77	6.28	6	5.48	3.17	1.71	1.06	3.42	3.02	5.34	1.31
Rajshahi	1.15	1.17	1.65	2.56	3.69	5.36	6.06	5.73	5.26	2.95	1.52	.95	3.17	2.63	5.07	1.20
Rangpur	1.27	1.21	1.68	3.13	4.43	5.68	6.07	5.70	5.17	3.01	1.31	.98	3.30	3.08	5.13	1.19
Syedpur	1.7	1.3	1.75	3.1	4.4	5.75	6.05	5.65	5.1	2.9	1.35	1.2	3.35	3.08	5.09	1.38
Chuadanga	.81	1.09	1.90	2.72	3.72	5.45	5.81	5.63	5.18	3.18	1.36	.63	3.12	2.78	5.05	.97

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
Jessore	1.16	1.45	2.09	3.10	4.29	5.75	6.2	6.07	5.6	3.56	1.72	.87	3.49	3.16	5.43	1.30
Khulna	.98	1.39	2	3	3.96	5.49	6.05	5.72	5.13	3.21	1.54	.90	3.28	2.98	5.12	1.20
Mongla	.85	1.33	2.09	3.28	4.23	5.61	5.95	5.71	5.33	3.38	1.85	1	3.38	3.20	5.2	1.26
Satkhira	1.14	1.47	2.16	3	3.98	5.4	5.83	5.74	5.21	3.43	1.89	.94	3.35	3.04	5.12	1.36
Barisal	1.01	1.41	2.45	3.76	4.73	6.2	6.51	6.35	5.65	3.55	1.85	1.05	3.71	3.65	5.65	1.33
Bhola	1.06	1.44	2.11	3.26	4.06	5.73	6.11	5.93	5.11	3.2	1.75	1.04	3.40	3.14	5.21	1.32
Khepupara	.76	1.26	2.20	3.58	4.73	6.02	6.52	6.29	5.55	3.64	1.91	.88	3.61	3.50	5.61	1.20
Patuakhali	1.09	1.51	2.33	3.69	4.51	5.84	6.45	6.09	5.45	3.51	1.93	1.06	3.62	3.51	5.47	1.40
Chadpur	.84	1.15	1.84	2.97	3.89	5.15	5.53	5.46	4.82	2.94	1.46	.82	3.07	2.90	4.78	1.07
Ambagan	.92	1.15	2.23	3.30	5	6.30	6.46	6.53	6	4.07	1.61	1	3.71	3.51	5.87	1.17
Chittagong	1.06	1.4	2.14	3.4	4.42	6	6.38	6.3	5.72	4.02	2.26	1.1	3.68	3.32	5.68	1.45
Comilla	.94	1.46	2.39	3.46	4.33	5.80	6.10	5.89	5.19	3.33	1.73	.87	3.46	3.39	5.26	1.25
Cox'sbazar	.94	1.12	1.82	3.03	4.39	6.36	6.70	6.63	5.82	3.86	2.10	1.82	3.67	3.08	5.87	1.35
Feni	1.05	1.57	2.48	3.94	4.94	6.22	6.71	6.4	5.62	3.45	1.94	.97	3.77	3.79	5.68	1.38
Hatiya	.92	1.45	2.32	3.25	4.35	6.05	6.27	5.82	4.9	2.95	1.85	1.02	3.43	3.30	5.2	1.31
Kutubdia	.96	1.23	1.92	2.80	4.23	5.92	6.34	6.15	5.38	3.53	1.92	1.03	3.45	2.98	5.46	1.28

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
M.court	.76	1.4	2.16	3.1	4.28	5.74	6.38	6.08	5.38	3.14	1.44	.7	3.38	3.18	5.34	1.07
Rangamati	1.5	1.52	2.14	3.06	4.29	5.68	5.93	5.89	5.31	4.04	2.83	2.29	3.71	3.16	5.37	2.03
Sandwip	.69	1.43	2.20	3.10	3.97	5.51	5.92	5.66	4.97	3.07	1.94	.84	3.27	3.09	5.03	1.23
Sitakunda	1	1.52	2.41	3.23	4.26	5.82	6	6	5.26	3.29	1.91	1.20	3.49	3.30	5.27	1.41
Teknaf	.57	1	1.63	2.63	4.15	6.39	6.57	6.60	5.57	3.57	2.06	1.33	3.51	2.80	5.74	1.24

Table A2: Average Monthly, Annual and Seasonal Variation of Temperature (ęc) at Different Locations of Bangladesh

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
Dinajpur	16.4	19.5	24.5	27.8	28.5	28.7	28.6	28.9	28.3	26.5	22.1	17.9	24.8	26.9	28.2	19.02
Rangpur	16.7	19.4	23.5	26.5	27.4	28.2	28.4	28.7	28.02	26.2	22.3	18.4	24.5	25.8	27.9	19.2
Rajshahi	16.9	20.1	25.2	29.1	29.4	29.2	28.6	28.7	28.3	28.7	22.6	28.2	25.3	27.9	28.3	19.4
Bogra	17.6	20.2	25.2	28.4	28.7	28.6	28.5	28.7	28.2	26.6	22.7	18.7	25.2	27.4	28.1	19.9
Mymensingh	17.7	20.5	24.9	27.5	27.9	28.3	28.3	28.5	28.2	26.9	23.4	19.2	25.1	26.8	28.09	20.2
Sylhet	18.2	20.3	24.1	25.7	26.5	27.2	27.6	27.9	27.5	26.1	22.9	19.4	24.4	25.4	27.3	20.2
Srimangal	16	19.1	24.1	26.9	27.4	27.6	27.7	27.8	27.4	25.9	21.5	17.2	24.1	26.1	27.3	18.4
Ishurdi	16.5	19.9	25.04	28.7	28.9	28.9	28.4	28.6	28.2	26.5	22.5	18	25	27.5	28.1	19.2
Dhaka	18.3	21.5	26.1	28.3	28.6	28.6	28.4	28.6	28.3	27.1	23.5	19.5	25.6	27.7	28.2	20.7
Comilla	18.4	21.3	25.2	27.4	28.2	28.1	27.9	28.1	28	27	23.4	19.4	25.2	26.9	27.8	20.6
Chadpur	18.6	21.6	26	28.3	29	28.7	28.4	28.5	28.4	27.5	24.2	20	25.8	27.8	28.3	21.1
Jessore	17.5	21	26	29.2	29.6	29.1	28.5	28.5	28.3	26.9	22.8	18.4	25.5	28.3	28.3	19.9
Faridpur	18	20.9	25.8	28.7	28.9	28.8	28.5	28.8	28.6	27.2	23.3	19	25.5	27.8	28.4	20.3
Madaripur	18.4	21.9	26.4	28.8	29.2	29	28.7	28.9	28.8	27.7	24.3	19.9	26	28.1	28.6	21.1

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre- Monsoon	Monsoon	Dry
Khulna	18.5	21.8	26.4	29.2	29.8	29.3	28.5	28.6	28.4	27.4	23.8	19.6	25.9	28.5	28.4	20.9
Satkhira	18.4	22	26.7	29.4	30.2	29.5	28.8	28.7	28.5	27.4	23.6	19.2	26.1	28.8	28.6	20.8
Barisal	18.3	21.5	26	28.4	29.1	28.6	28.1	28.2	28.2	27.2	23.6	19.4	25.5	27.8	28.1	20.7
Bhola	18.1	21.4	25.7	28	28.6	28.3	27.9	28.1	28	27.1	23.7	19.4	25.4	27.4	27.9	20.6
Feni	18.4	21.6	25.6	27.5	28.1	28	27.7	28	28	27.2	23.9	19.7	25.3	27.1	27.8	20.9
M.court	18.7	21.5	25.5	28.1	28.7	28.3	27.9	28.1	28.1	27.5	24	20	25.5	27.4	28.04	21.08
Hatiya	19.2	22.1	25.8	28	28.8	28.3	27.8	27.9	28	27.4	24.4	20.5	25.7	27.5	27.9	21.5
Sitakunda	18.7	21.7	25.4	27.8	28.5	28.2	27.7	28	28.1	27.4	24	20	25.5	27.2	27.9	21.1
Sandwip	19.6	22.2	25.9	28.1	28.8	28.4	27.9	28	28.3	27.9	24.9	21	25.9	27.6	28.1	21.9
Kutubdia	20.1	22.4	25.5	27.8	28.8	28.1	27.5	27.8	27.9	27.7	24.9	21.5	25.8	27.4	27.8	22.2
Cox’sbazar	20.3	22.4	25.7	28.1	28.7	27.7	27.2	27.3	27.6	27.3	24.7	21.3	25.7	27.5	27.4	22.2
Teknaf	21.4	23.3	26.2	28.3	29	27.8	27.4	27.5	27.9	27.8	25.6	22.5	26.2	27.8	27.7	23.2
Rangamati	18.5	21.4	25.4	27.8	28.2	27.8	27.4	27.5	27.6	26.8	23.6	19.9	25.2	27.1	27.4	20.9
Potuakhali	18.9	22.3	26.3	28.5	29.2	28.8	28.3	28.4	28.3	27.5	24.3	20.2	25.9	28	28.3	21.4
Khepupara	19.3	22.6	26.6	28.7	29.5	29.3	28.4	28.4	28.3	27.6	24.4	20.4	26.1	28.3	28.4	21.7
Syedpur	16.1	19.9	24	26.4	27.9	28.7	29	29.3	28.5	26.5	22.4	18.2	24.7	26.1	28.4	19.2

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
Tangail	16.8	20.4	24.8	27.7	28.3	28.6	28.5	28.7	28.3	26.8	22.9	18.6	25	27	28.2	19.7
Mongla	18.9	22.5	26.9	29.3	29.8	29.3	28.7	28.6	28.4	27.5	24.4	20.3	26.2	28.7	28.5	21.5
Chuadanga	16.3	20.5	25.4	28.9	29.3	29.1	28.5	28.6	28	26.5	22.4	17.8	25.1	27.9	28.1	19.2
Chittagong	19.7	22.1	25.6	27.8	28.6	28.1	27.7	27.9	28	27.4	24.4	20.7	25.7	27.3	27.8	21.7
Ambagan	19.8	23	26.4	28.4	28.6	28.2	27.9	28	28.1	27.5	24.4	20.8	25.9	27.8	27.9	22

Table B3: Average Monthly, Annual and Seasonal Variation of Relative Humidity (%) at Different Locations of Bangladesh

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
Dhaka	70.2	63.4	61.6	70.2	77.4	83.8	84.8	83.9	83.7	79.5	73.5	72.8	75.4	69.7	83.1	70
Tangail	80	73.9	69.4	73.7	79	84.2	85.5	85.1	85.3	82.9	80.2	81.1	80	74	86.6	78.8
Mymensingh	75.6	70.1	68.2	72.8	80	85.9	86.6	85.7	85.8	83.4	78.6	78.1	79.2	73.7	85.5	75.6
Faridpur	76.7	70.8	66.1	71.1	78.4	85.6	87	85.7	85.2	82	78.1	77.9	78.7	71.9	85.1	75.9
Madaripur	75.2	70.7	68.2	73.7	78.6	84.6	85.9	84.8	84.1	80.6	76.8	76.5	78.3	73.5	84	74.8
Srimangal	82.2	74.6	70.1	73.2	79.6	85	85.9	86.3	86.8	86	84.3	84.6	81.6	74.3	86	81.4
Sylhet	73.6	67.3	65.9	75.4	81.4	87.2	87.3	86.6	86.1	82.9	76.7	74.7	78.8	74.2	86	73.1
Bogra	74.3	66.7	61.9	66.1	77.1	84.5	86.3	85.6	85.6	82.2	76.7	75.9	76.9	68.4	84.8	73.4
Dinajpur	75.8	66.8	58.5	61.5	73.7	81.8	84.8	84.4	84.8	81	76.2	76.7	75.5	64.6	83.4	73.9
Ishurdi	74.3	67.4	59.4	64	74	82.6	86	85.3	85.2	82	76.8	75.6	76	65.8	84.2	73.5
Rajshahi	75.5	68.5	60.2	63.2	73.3	82.6	87	86.1	85.6	81.9	77.2	76.6	76.5	65.6	84.6	74.4
Rangpur	81.7	75.3	68.1	72.3	79.9	85	86.2	85.3	86.4	84.5	81.4	81.7	80.6	73.4	85.5	80
Sydpur	77.4	69	62.5	69	76.5	71.8	83.2	82.7	83.2	79.3	74.6	75.5	76.2	69.3	82	74.1
Chuadanga	77.4	71.7	64.8	68	74.5	82.5	86.3	85.9	86.2	82.8	77.8	77.9	78	69.1	84.7	76.2

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
Jessore	75.1	70.1	66.3	69.6	75.6	84.3	87.1	87	86.3	82.7	77.8	76.7	78.2	70.5	85.5	74.9
Khulna	75.2	72.4	71	74.9	78.3	85.4	87.8	87.1	86.9	83.2	78.2	76.9	79.8	74.7	86.1	75.7
Mongla	75.2	73	72.9	76.8	79.9	86.3	88.2	88.3	88.6	85.1	80.1	77	80.9	76.5	83.7	76.3
Satkhira	74	70.8	68.2	72.3	74.5	82.3	85.9	86.3	85.9	82	76	74.7	77.7	71.7	84.5	73.9
Barisal	78.4	75.3	73.6	78.5	81.6	87.4	88.9	88.8	87.9	85.5	81.3	79.9	82.2	77.9	87.7	78.7
Bhola	80.4	77.2	77.3	81.3	83.8	88.5	89.9	88.9	88.5	86.2	82.7	81.5	83.8	80.8	88.4	80.4
Khepupara	74.4	73.5	75.2	78.5	80.9	85.8	88.1	87.5	86.9	84.8	80.6	76.9	81.1	78.2	86.6	76.3
Potuakhali	77.6	74.7	75.2	80.3	82.7	87.9	89.7	88.8	88.3	85.5	81.8	79.2	82.6	79.4	88	78.3
Chadpur	76.8	72.8	72	76.4	79.4	85	86.4	85.6	85.4	82.1	78.3	77.8	79.8	76	84.9	76.4
Teknaf	66.7	66.3	71.4	76.5	79.4	87.3	89.1	88.8	86.1	82.4	75.4	69.9	78.3	75.8	86.7	69.6
Ambagan	72.6	66.2	70.1	76.7	80.5	85.8	86.7	85.9	84.9	83.9	79.1	77.1	79.1	75.8	85.4	73.7
Comilla	75.4	72.2	74.1	78.7	81.4	86.1	87.1	86.5	85.8	83.5	79.7	78	80.7	78.1	85.8	76.3
Cox'sbazar	72	71.7	75.2	78	80.2	87.3	89.2	88.6	86.2	82.7	77.2	74.2	80.2	77.8	86.8	73.8
Feni	74.8	71.4	73.2	78.3	81.2	85.3	87.3	85.9	85.4	83.7	79.2	77	80.2	77.6	85.5	75.6
Hatiya	74.4	72.9	75.2	78.8	81.7	87	88.9	88.2	86.4	84.1	79.7	77.9	81.3	78.6	86.9	76.2
Kutubdia	74.4	75.5	79.3	80.4	81.1	85.8	87.9	87	85.8	83.1	78.8	75.9	81.3	80.4	85.9	76.1

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
M.Court	76.8	74.5	75.4	77.7	80.7	86.1	87.6	86.9	85.9	83.4	79.6	79	81.1	78	86	77.5
Rangamati	76.7	70.2	67.5	71.9	77.6	84	85.7	85.6	84.5	83.5	81.7	80.6	79.1	72.3	84.7	77.3
Sandwip	78.9	77.2	79.1	81.5	83.7	88	89.8	88.6	86.9	84.1	81.7	80.4	83.3	81.4	87.5	79.5
Chittagong	72.5	70.7	74.2	77.9	80.1	84.8	86.6	86.2	84.4	82.4	78	75.6	79.5	77.4	84.9	74.2
Sitakunda	73	69.8	72.9	77.5	80	84.6	86.8	85.7	84.5	82.3	78.4	76.1	79.3	76.8	84.8	74.3

Table B4: Average Monthly, Annual and Seasonal Variation of Rainfall (mm/day) at Different Locations of Bangladesh

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
Dhaka	.23	.73	1.77	4.32	8.74	12.07	12.49	10.12	9.68	5.49	.91	.27	5.57	4.94	9.97	.53
Tangail	.19	.86	1.46	3.63	8.36	10.5	10.69	8.75	9.41	5.37	.83	.37	5.03	4.48	8.94	.56
Faridpur	.20	.77	1.35	4.12	7.43	11.63	11.53	9.46	8.19	5.50	.99	.26	5.12	4.30	9.26	.56
Mymensingh	.29	.65	1.30	3.69	10.06	14.02	13.28	11.32	10.11	6.02	.60	.19	5.96	5.02	10.95	.43
Madaripur	.18	.80	1.55	3.95	7.63	12.56	12.61	10.60	8.84	5.02	1.07	.14	5.41	4.38	9.93	.55
Srimangal	.23	.79	1.98	4.93	9.36	12.72	11.92	10.36	9.76	5.65	1.07	.26	5.75	5.42	10.08	.59
Sylhet	.31	1.24	3.98	11.79	18.32	26.39	24.43	20.14	16.74	6.90	.86	.27	10.95	11.36	18.92	.67
Bogra	.27	.41	.88	2.09	5.87	10.48	11.8	10.25	9.11	4.82	.40	.21	4.72	2.95	9.29	.32
Dinajpur	.33	.27	.55	2	6.03	12.11	13.93	11.26	10.57	4.41	.26	.17	5.16	2.86	10.46	.26
Ishurdi	.25	.59	.90	2.64	5.50	9.05	10.34	7.56	8.79	3.81	.47	.28	4.18	3.01	7.91	.40
Rajshahi	.29	.46	.78	1.90	4.35	8.82	10.29	8.23	8.93	3.83	.35	.27	4.04	2.35	8.02	.34
Rangpur	.27	.32	.95	3.05	8.64	15.46	15.30	11.28	10.86	5.28	.25	.22	5.99	4.21	11.64	.26
Sydpur	.31	.24	.85	3.01	8.15	15.02	14.08	11	12.77	5.49	.34	.18	5.95	4	11.67	.27
Chuadanga	.36	.73	.91	1.47	4.79	7.90	10.93	7.30	10.72	4.29	.56	.29	4.19	2.39	8.23	.49

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
Jessore	.38	.75	1.39	2.22	5.14	9.94	10.35	8.95	7.94	4.26	.71	.30	4.36	2.92	8.29	.53
Khulna	.30	.88	1.42	2.40	5.40	11.08	11.14	9.46	8.81	4.54	.93	.14	4.71	3.07	9.01	.56
Mongla	.32	.91	1.39	1.97	5.66	11.78	12.30	10.68	11.18	5.73	1.35	.08	5.28	3.01	10.33	.66
Satkhira	.38	.91	1.14	2.49	5.11	9.98	10.87	9.52	9.11	4.59	.88	.18	4.60	2.91	8.82	.59
Barisal	.30	.76	1.56	3.11	6.37	13.63	13.57	11.61	9.69	6.06	1.36	.28	5.69	3.68	10.91	.68
Bhola	.23	.89	1.68	3.64	7.51	14.65	14.74	12.60	10.07	5.97	2.11	.17	6.19	4.28	11.61	.85
Khepupara	.28	.68	1.46	2.98	8.66	16.36	21	14.57	12.7	8.84	1.61	.19	7.44	4.37	14.69	.69
Potuakhali	.26	.80	1.32	3.53	7.88	17.69	18.80	14.82	12.87	6.74	1.44	.12	7.19	4.25	14.18	.66
Chandpur	.17	.60	2.05	4.50	8.43	12.15	13.92	11.10	9.17	4.98	.94	.20	5.68	5.00	10.27	.48
Teknap	.10	.42	.41	2.17	9.26	31.89	34.80	28.41	14.71	7.94	2.21	.42	11.06	3.95	23.55	.79
Chittagong	.18	.68	1.83	3.77	8.97	20.14	23.19	17.70	9.41	7.00	1.85	.28	7.92	4.86	15.49	.75
Comilla	.22	.83	1.79	4.71	9.49	14.65	14.62	11.50	9.07	5.62	1.34	.23	6.17	5.33	11.09	.66
Cox'sbazar	.22	.55	.85	2.92	10.03	27.68	31.40	23.04	12.75	8.23	2.50	.39	10.06	4.60	20.62	.91
Feni	1.67	1.00	2.00	5.34	11.92	17.92	22.90	16.59	11.62	6.08	1.56	.23	8.11	6.42	15.02	.74
Hatiya	.13	.55	1.58	3.86	9.28	20.17	24.14	18.29	14.42	6.98	1.34	.36	8.42	4.91	16.8	.60
Kutubdia	.20	.70	1.29	2.50	8.22	20.66	23.43	15.93	10.38	6.23	2.04	.27	7.65	4.00	15.33	.80

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
M.cuort	.37	.75	2.05	3.94	10.44	19.73	23.05	19.44	12.86	6.75	1.38	.21	8.42	5.48	16.37	.68
Rangamati	.14	.59	1.58	3.82	9.46	16.12	17.81	13.70	9.38	5.67	1.60	.45	6.69	4.95	12.54	.69
Sandwip	.27	.79	1.86	4.64	10.96	22.43	27.10	21.59	14.71	8.11	1.87	.25	9.55	5.82	18.79	.79
Ambagan	.23	.23	.85	3.23	11.89	21.05	20.93	15.91	10.94	7.40	1.51	.46	7.88	5.32	15.24	.61
Sitakunda	.14	.61	2.19	4.87	11.22	18.27	22.20	18.42	12.73	7.30	1.59	.20	8.31	6.09	15.79	.64

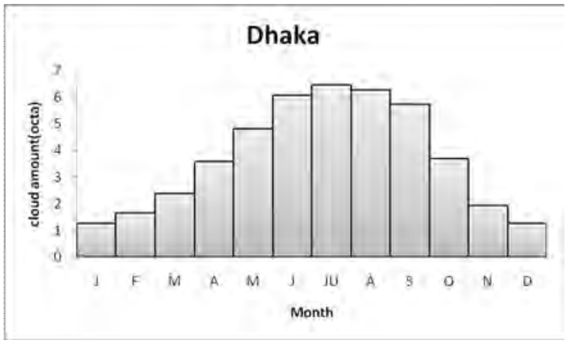
Table B5: Average Monthly, Annual and Seasonal Variation of Total Rainfall (mm/day) at Different Locations of Bangladesh

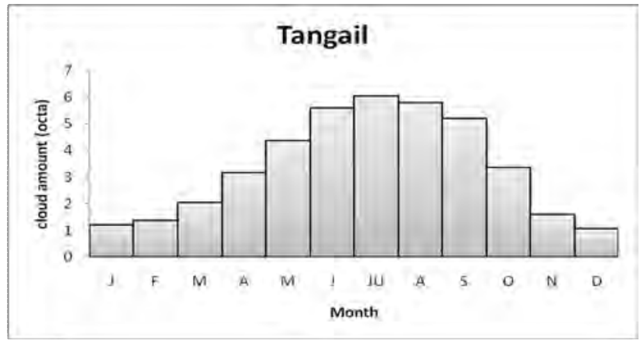
Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
Dhaka	7.2	21.3	54.9	129.8	271.1	362.2	387.3	313.7	290.4	170.4	27.3	8.6	2044.8	455.9	1524.2	64.5
Tangail	6.1	24.9	45.4	109	259.3	315	331.5	271.5	282.3	166.6	25.1	11.4	1848.5	413.7	1367	67.7
Faridpur	6.4	22.4	42.1	123.8	230.4	349	357.6	293.3	245.8	170.5	29.9	8	1879.6	396.3	1416.3	66.9
Mymensingh	9.1	19	40.3	110.8	312	420.7	411.8	351.1	303.3	186.8	18	5.9	2189.4	463.2	1673.9	52.2
Madaripur	5.7	23.2	48.2	118.6	236.7	377	391.1	328.7	265.4	155.6	32.2	4.4	1987.3	403.6	1517.9	65.7
Srimangal	7.3	23.1	61.5	147.9	290.4	381.7	369.6	321.3	292.9	175.3	32.1	8.3	2111.7	499.8	1540.9	70.9
Sylhet	9.6	36	123.6	353.7	568.1	791.8	757.6	624.5	502.4	214	25.9	8.6	4016.2	1045.5	2890.5	80.2
Bogra	8.5	12.1	27.5	62.7	182.1	314.4	365.8	317.9	273.5	149.5	12	6.5	1732.9	272.3	1421.2	39.2
Dinajpur	10.4	8	17.2	60	187.1	363.5	431.9	349.1	317.2	136.7	8	5.4	1894.9	264.4	1598.6	31.8
Ishurdhi	7.7	17.2	28.1	79.3	170.6	271.6	320.8	234.4	263.8	118.2	14.3	8.8	1535.2	278.1	1208.9	48.1
Rajshahi	9.2	13.4	24.4	57.2	135	264.7	319.1	255.3	268.1	118.7	10.7	8.5	1484.9	216.7	1226.1	41.9
Rangpur	8.5	9.2	29.4	91.7	267.9	464	474.4	349.9	326	163.9	7.7	7	2200.2	389.2	1778.4	32.5
Sydpur	9.6	7	26.6	90.4	252.7	450.6	436.6	341.1	383.1	170.3	10.4	5.8	2184.7	369.8	1781.9	32.9
Chuadanga	11.3	21.3	28.4	44.3	148.6	237.1	338.9	226.5	321.7	133	17	9.2	1537.8	221.3	1257.5	58.9

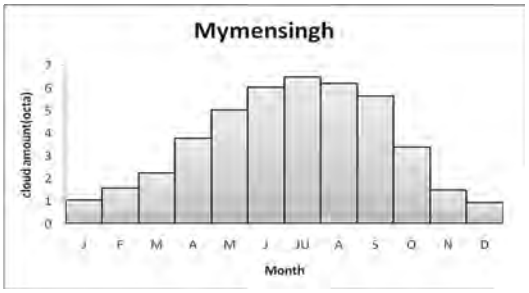
Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
Jessore	11.9	21.8	43.3	66.7	159.6	298.3	321	277.5	238.4	132.3	21.4	9.3	1601.8	269.7	1267.5	64.5
Khulna	9.4	25.5	44.1	72	167.4	332.5	345.6	293.3	264.3	140.9	27.9	4.3	1727.9	283.7	1376.9	67.2
Mongla	10	26.6	43	59.3	175.5	353.4	381.3	331.3	335.5	177.8	40.5	2.6	1937.4	278	1579.5	79.8
Satkhira	11.7	26.4	35.4	74.9	158.5	299.6	337.1	295.4	273.4	142.3	26.6	5.8	1687.6	268.9	1348	70.6
Barisal	9.4	22.3	48.4	93.5	197.6	409	420.8	359.9	290.8	188.1	40.8	8.9	2090.2	339.7	1668.8	61.6
Bhola	7.2	25.8	52	109.4	232.9	439.5	457.1	390.7	302.3	185.2	63.3	5.5	2271.7	394.4	1775.1	102
Khepupara	8.8	19.9	45.3	89.4	268.7	490.8	651.1	451.8	381.1	274.3	48.5	6.1	2736.3	403.5	2249.2	83.5
Potuakhali	8.3	23.4	41.2	106.1	244.5	530.7	582.8	459.6	386.3	209.2	43.3	4	2639.8	391.8	2168.8	79
Chadpur	5.3	17.4	63.7	135.1	261.5	364.7	431.7	344.2	275.1	154.6	28.2	6.3	2088.5	460.5	1570.5	57.4
Teknaf	3.1	12.3	12.8	65.2	287.2	956.8	1079	880.9	441.5	246.3	66.5	13.1	4065.2	365.3	3604.6	95.2
Chittagong	5.7	19.7	56.9	113.2	278.1	604.4	719	548.8	282.4	217.2	55.8	8.7	2910.2	448.2	2372	89.9
Comilla	7.1	24.2	55.5	141.5	294.2	439.5	453.3	356.6	272.1	174.3	40.3	7.3	2266.6	491.3	1696.2	79
Cox'sbazar	7	15.9	26.6	87.6	310.9	830.6	973.5	714.4	382.5	255.3	75.1	12.1	3692	425.2	3156.4	110
Feni	5.2	29	62.1	160.4	369.7	537.7	710	514.3	348.7	188.7	46.8	7.3	2980.3	592.2	2299.6	88.4
Hatiya	4.1	16.1	49.1	116	287.7	605.1	748.4	567	432.6	216.3	40.4	11.3	3094.9	453	2569.7	72.1
Kutubdia	6.2	20.4	40	75.1	255	619.8	726.4	494.1	311.6	193.1	61.4	8.4	2811.9	370.1	2345.2	96.5

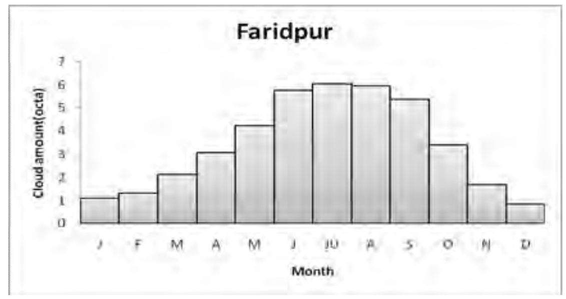
Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Dry
M.court	11.7	21.9	63.7	118.4	323.8	592	714.6	602.7	386	209.4	41.6	6.5	3092.8	506	2504.9	81.8
Rangamati	4.3	17.3	49.2	114.7	293.3	483.7	552.2	424.9	281.6	176	48.1	14.1	2459.8	457.3	1918.5	83.9
Sandwip	8.5	22.9	57.8	139.3	339.9	673.1	840.1	669.5	441.3	251.5	56.3	7.9	3508.5	537.2	2875.6	95.7
Ambagan	7.3	6.9	26.6	96.9	368.6	631.5	648.8	493.2	328.3	229.4	45.3	14.3	2897.8	492.2	2331.4	74.1
Sitakunda	4.5	17.9	68.1	146.1	348	548.2	688.4	571.2	381.9	226.5	47.8	6.5	3055.6	562.4	2416.4	76.8

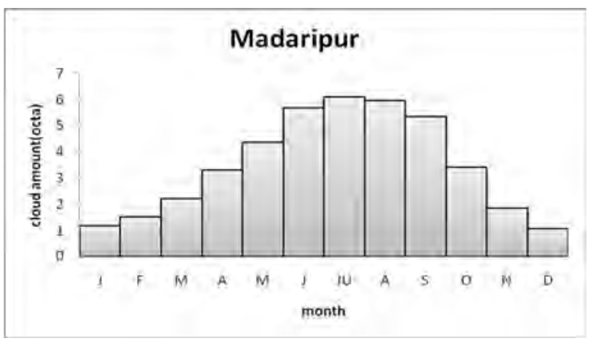
APPENDIX B
TEMPORAL VARIATION AND TREND ANALYSIS OF CLOUD COVER

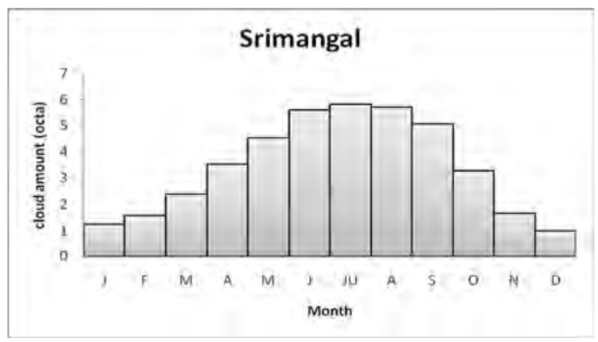

Dhaka
cloud amount(octa)
Month

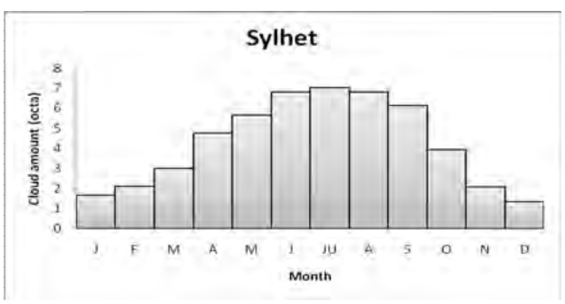

Tangail
cloud amount (octa)
Month

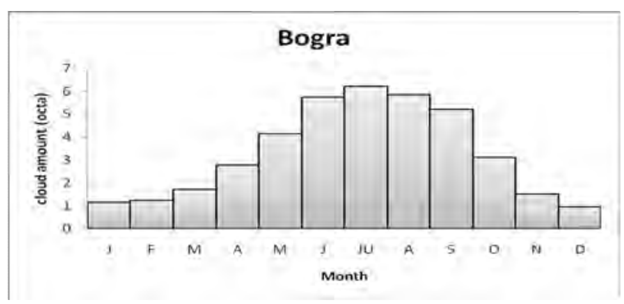

Mymensingh
cloud amount(octa)
Month

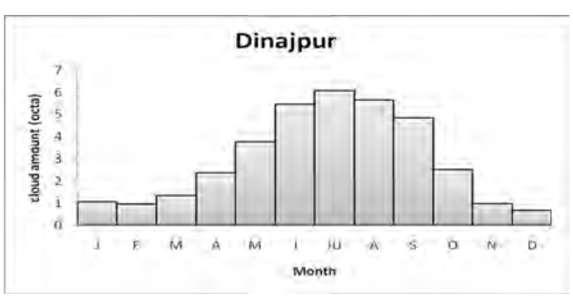

Faridpur
Cloud amount(octa)
Month

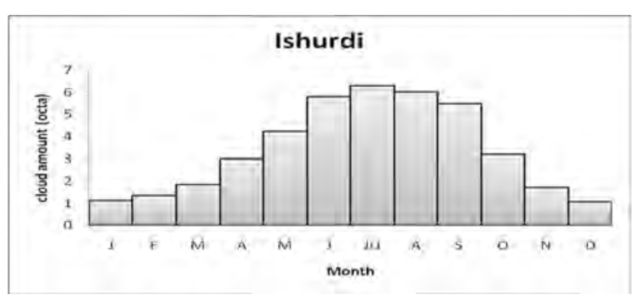

Madaripur
cloud amount(octa)
month

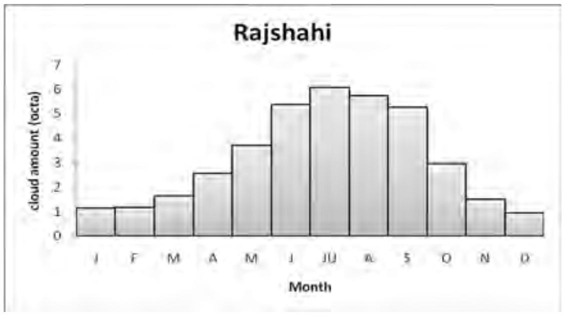

Srimangal
cloud amount (octa)
Month

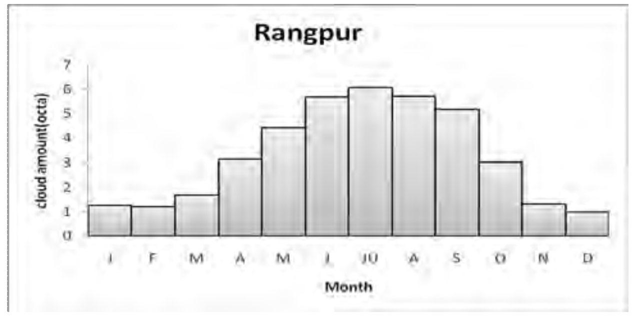

Sylhet
Cloud amount (octa)
Month

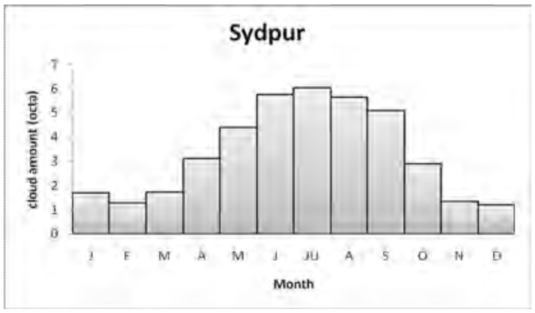

Bogra
cloud amount (octa)
Month

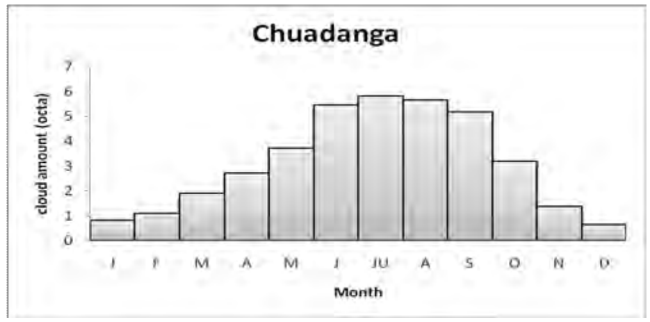

Dinajpur
cloud amount (octa)
Month

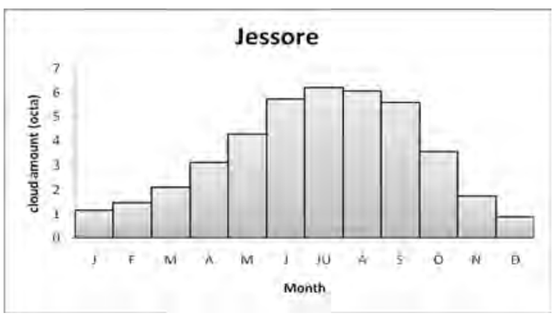

Ishurdi
cloud amount (octa)
Month

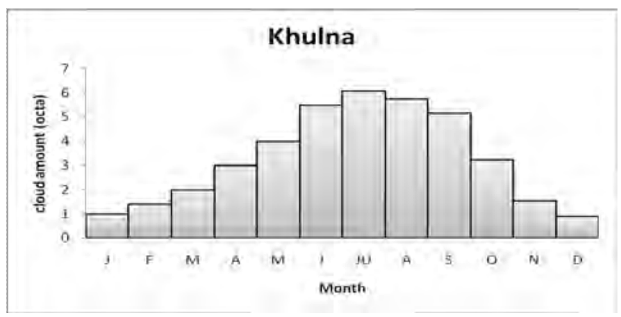

Rajshahi
cloud amount (octa)
Month
J F M A M J JU A S O N D

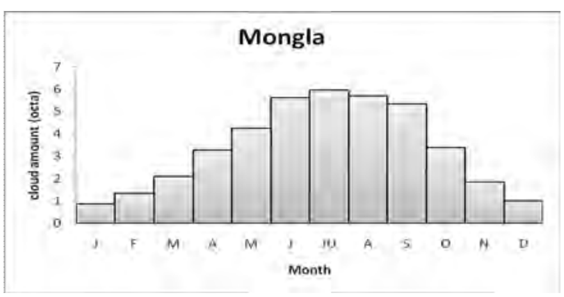

Rangpur
cloud amount(octa)
Month
J F M A M J JU A S O N D


Sydpur
cloud amount (octa)
Month
J F M A M J JU A S O N D

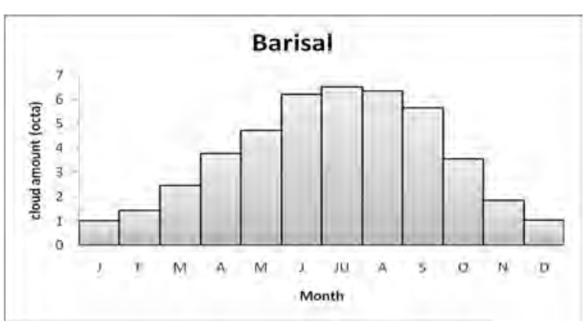

Chuadanga
cloud amount (octa)
Month
J F M A M J JU A S O N D

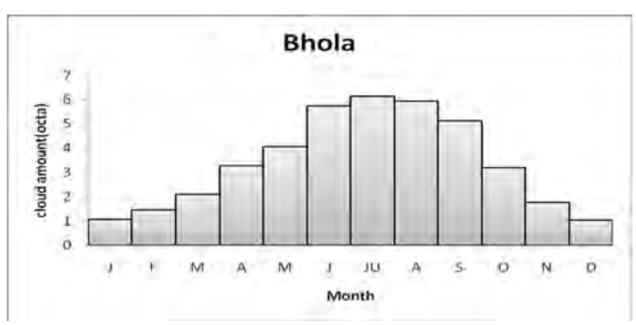

Jessore
cloud amount (octa)
Month
J F M A M J JU A S O N D

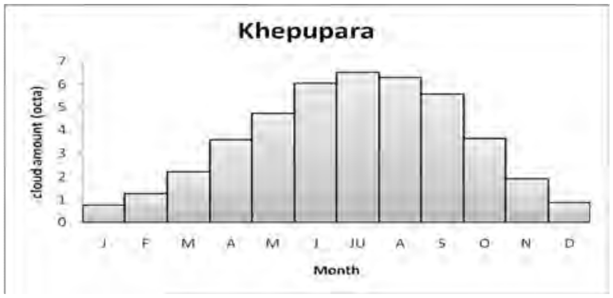

Khulna
cloud amount (octa)
Month
J F M A M J JU A S O N D

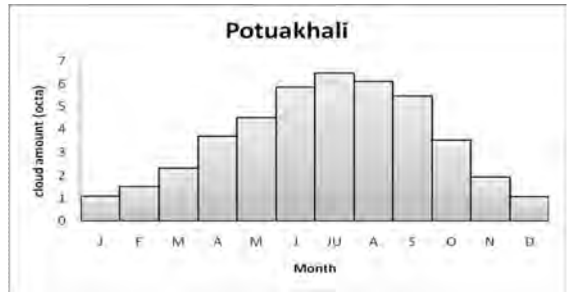

Mongla
cloud amount (octa)
Month
J F M A M J JU A S O N D

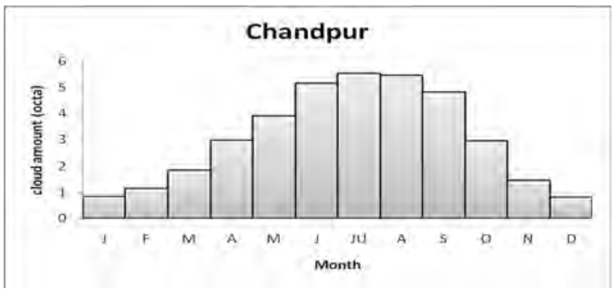

Satkhira
cloud amount (octa)
Month
J F M A M J JU A S O N D

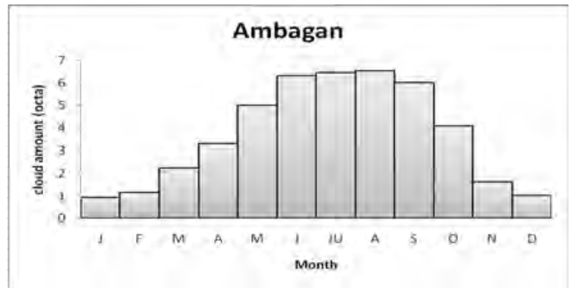

Barisal
cloud amount (octa)
Month
J F M A M J JU A S O N D


Bhola
cloud amount(octa)
Month
J F M A M J JU A S O N D

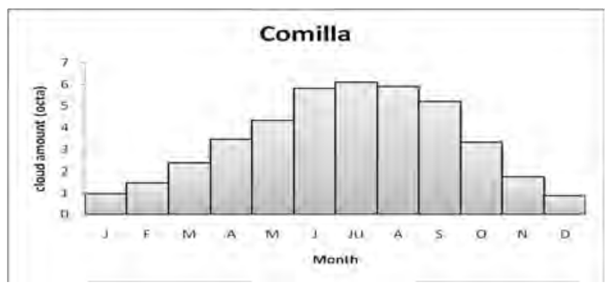

Khepupara
cloud amount (octa)
J F M A M J JU A S O N D
Month

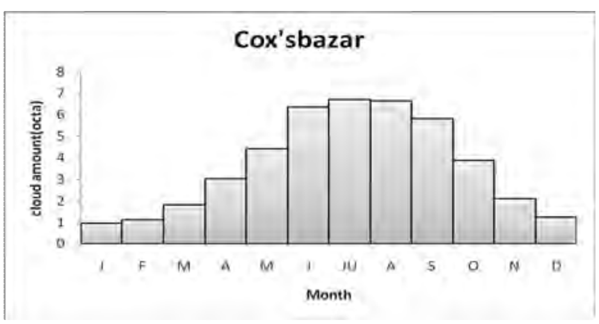

Potuakhali
cloud amount (octa)
J F M A M J JU A S O N D
Month

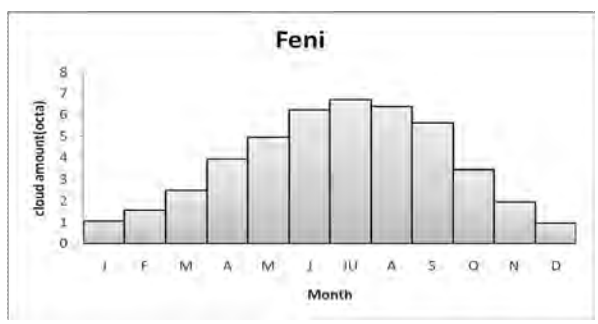

Chandpur
cloud amount (octa)
J F M A M J JU A S O N D
Month

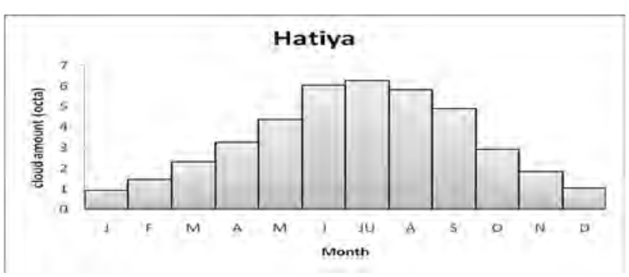

Ambagan
cloud amount (octa)
J F M A M J JU A S O N D
Month

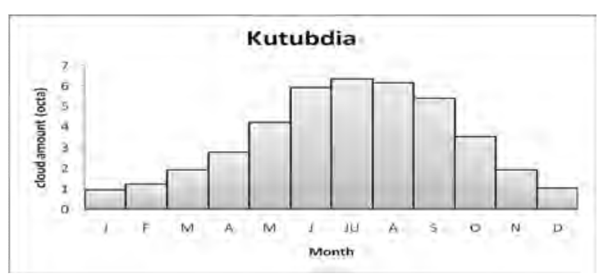

Chittagong
cloud amount (octa)
J F M A M J JU A S O N D
Month

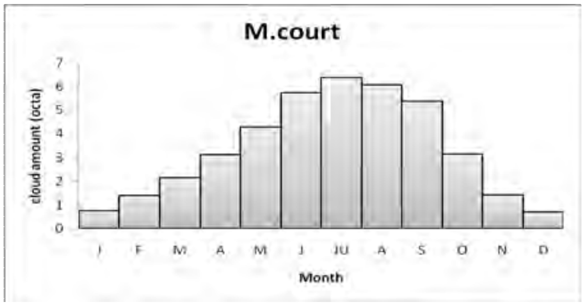

Comilla
cloud amount (octa)
J F M A M J JU A S O N D
Month

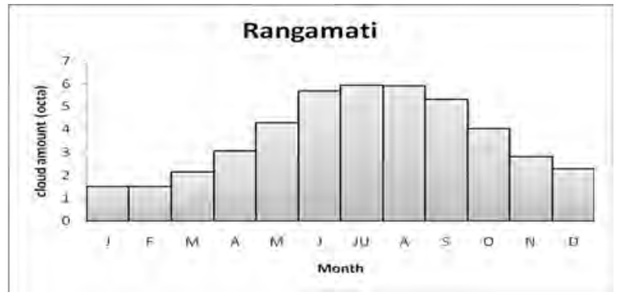

Cox'sbazar
cloud amount(octa)
J F M A M J JU A S O N D
Month

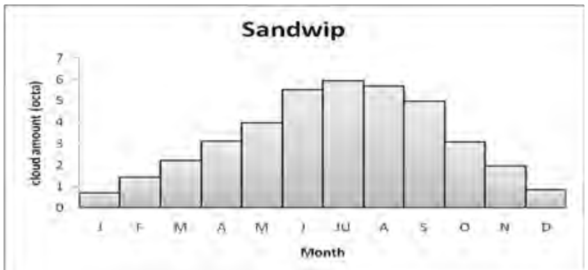

Feni
cloud amount(octa)
J F M A M J JU A S O N D
Month


Hatiya
cloud amount (octa)
J F M A M J JU A S O N D
Month

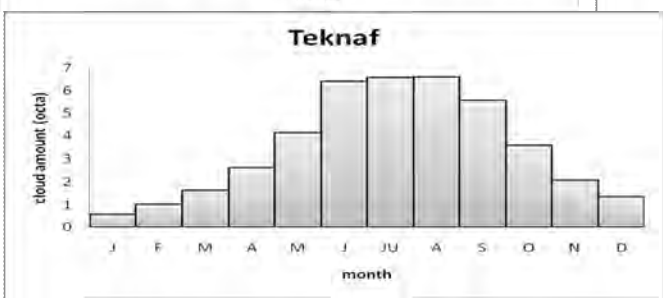

Kutubdia
cloud amount (octa)
J F M A M J JU A S O N D
Month

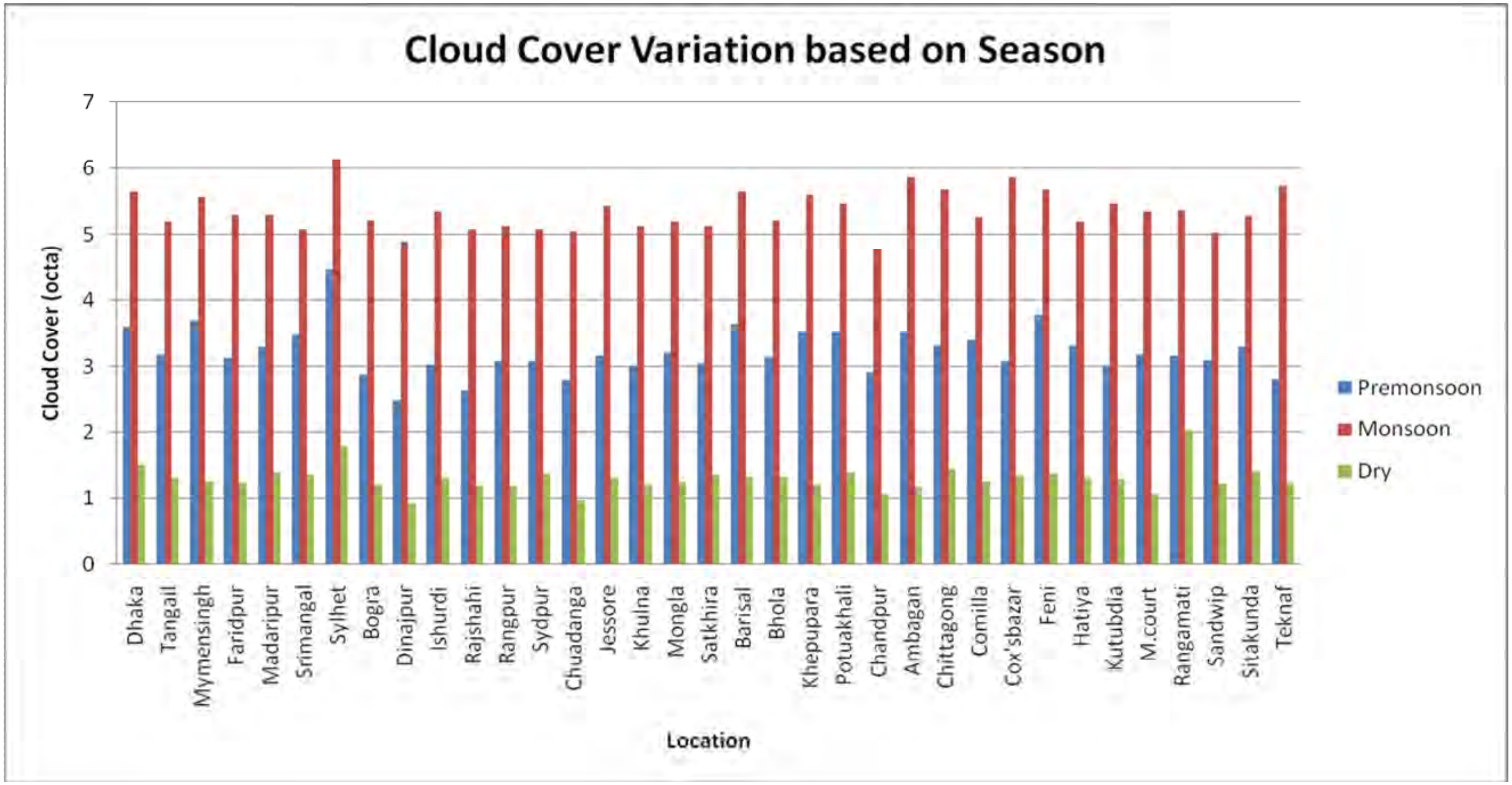

M.court
cloud amount (octa)
0 1 2 3 4 5 6 7
J F M A M J JU A S O N D
Month

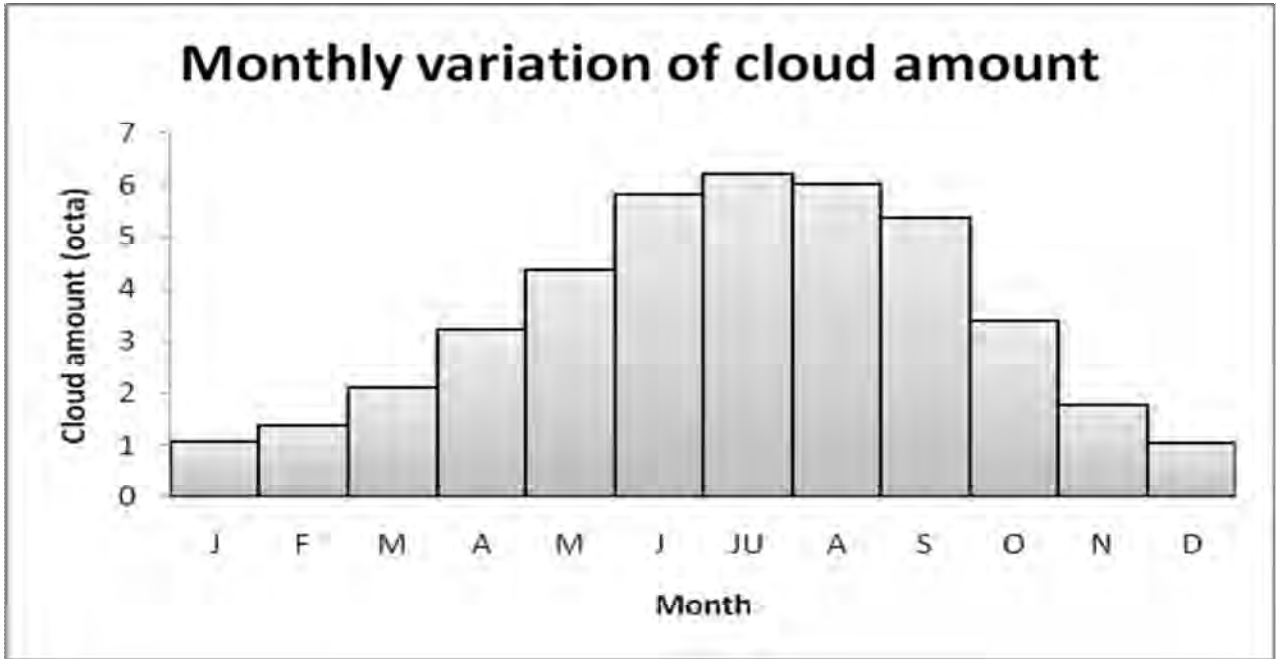

Rangamati
cloud amount (octa)
0 1 2 3 4 5 6 7
J F M A M J JU A S O N D
Month

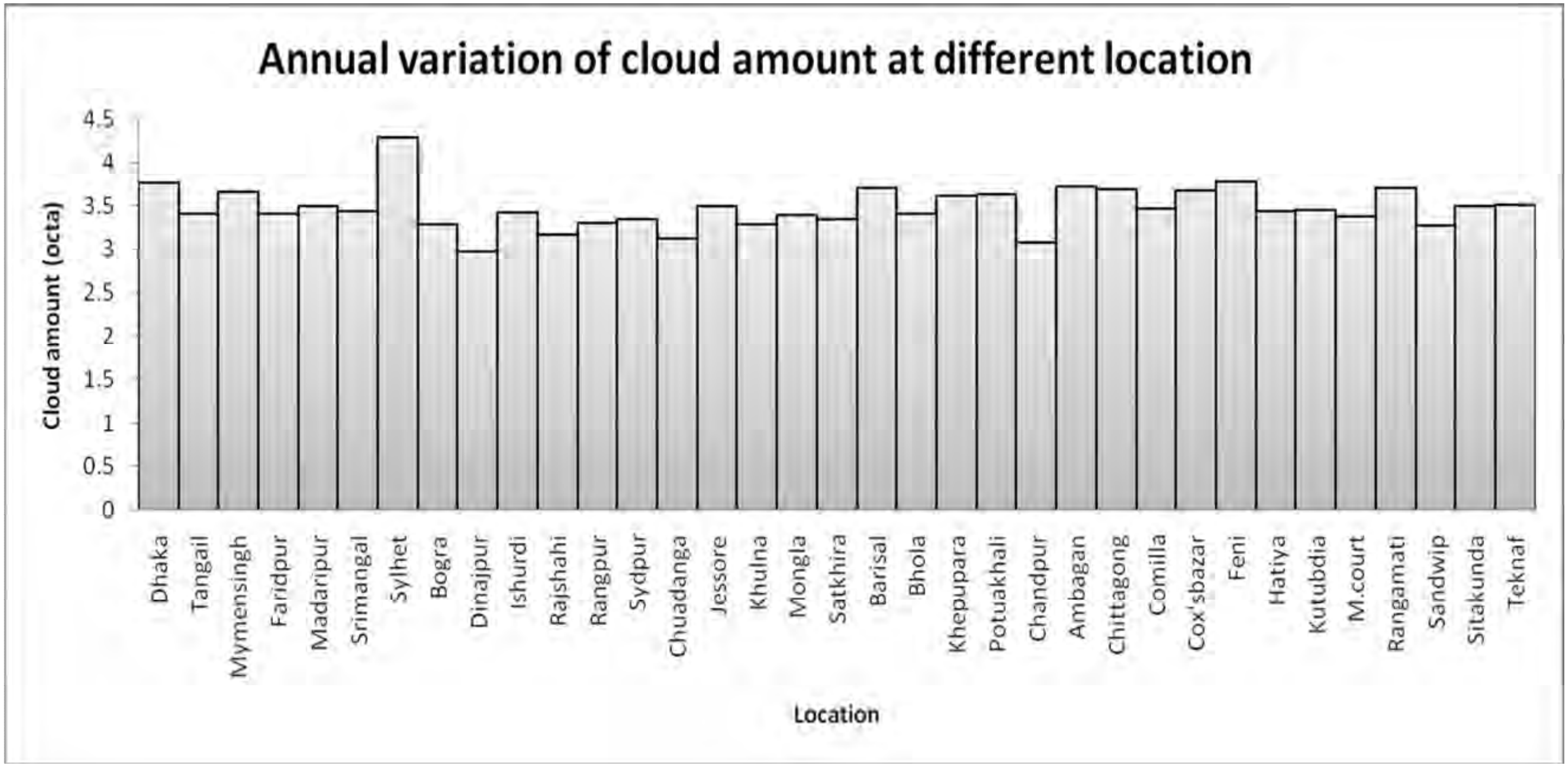

Sandwip
cloud amount (octa)
0 1 2 3 4 5 6 7
J F M A M J JU A S O N D
Month

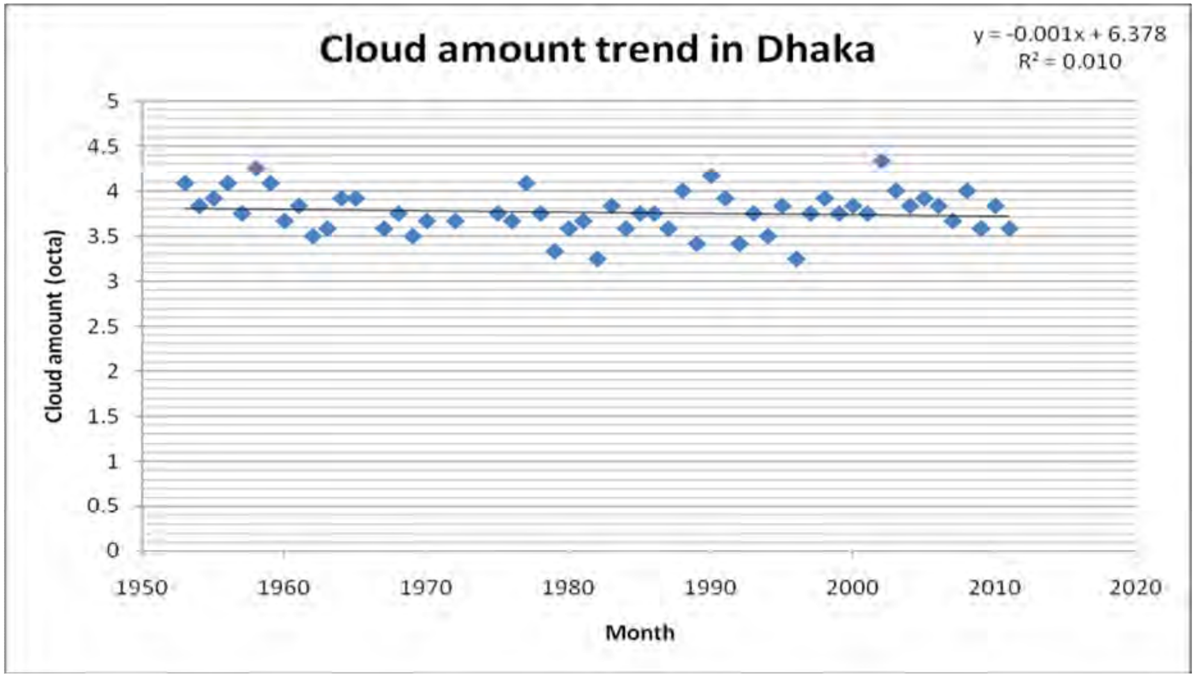

Sitakunda
cloud amount(octa)
0 1 2 3 4 5 6 7
J F M A M J JU A S O N D
Month

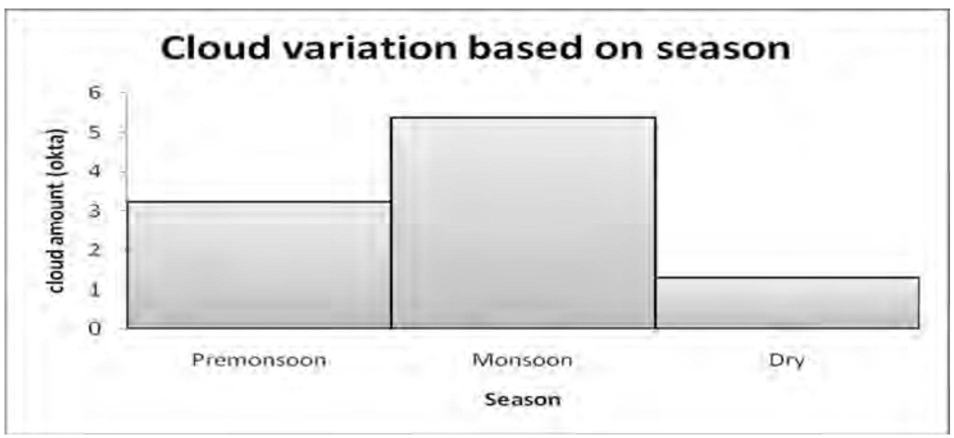

Teknaf
cloud amount (octa)
0 1 2 3 4 5 6 7
J F M A M J JU A S O N D
month


Cloud Cover Variation based on Season
Cloud Cover (octa)
0
1
2
3
4
5
6
7
Dhaka
Tangail
Mymensingh
Faridpur
Madaripur
Srimangal
Sylhet
Bogra
Dinajpur
Ishurdi
Rajshahi
Rangpur
Sydpur
Chuadanga
Jessore
Khulna
Mongla
Satkhira
Barisal
Bhola
Khepupara
Potuakhali
Chandpur
Ambagan
Chittagong
Comilla
Cox'sbazar
Feni
Hatiya
Kutubdia
M.court
Rangamati
Sandwip
Sitakunda
Teknaf
Location
Premonsoon
Monsoon
Dry


Monthly variation of cloud amount
Cloud amount (octa)
7
6
5
4
3
2
1
0
J
F
M
A
M
J
JU
A
S
O
N
D
Month

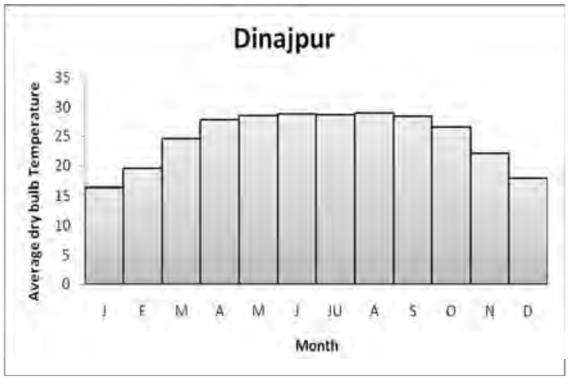

Annual variation of cloud amount at different location
Cloud amount (octa)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Dhaka
Tangail
Mymensingh
Faridpur
Madaripur
Srimangal
Sylhet
Bogra
Dinajpur
Ishurdi
Rajshahi
Rangpur
Sydpur
Chuadanga
Jessore
Khulna
Mongla
Satkhira
Barisal
Bhola
Khepupara
Potuakhali
Chandpur
Ambagan
Chittagong
Comilla
Cox'sbazar
Feni
Hatiya
Kutubdia
M.court
Rangamati
Sandwip
Sitakunda
Teknaf
Location

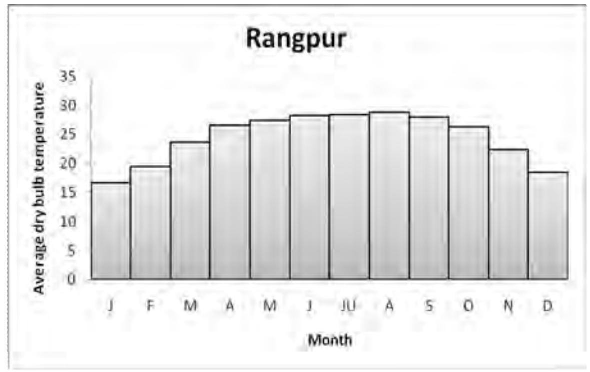

Cloud amount trend in Dhaka
y = -0.001x + 6.378
R² = 0.010
Cloud amount (octa)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1950
1960
1970
1980
1990
2000
2010
2020
Month

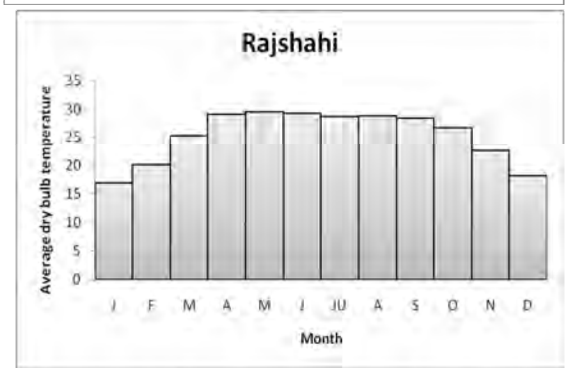

Cloud variation based on season
cloud amount (okta)
6
5
4
3
2
1
0
Premonsoon
Monsoon
Dry
Season

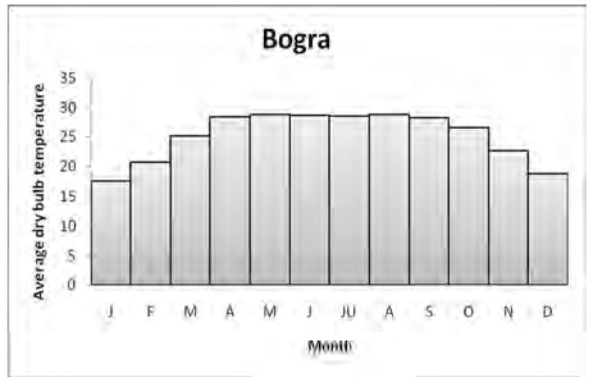
APPENDIX C
TEMPORAL VARIATION AND TREND ANALYSIS OF TEMPERATURE

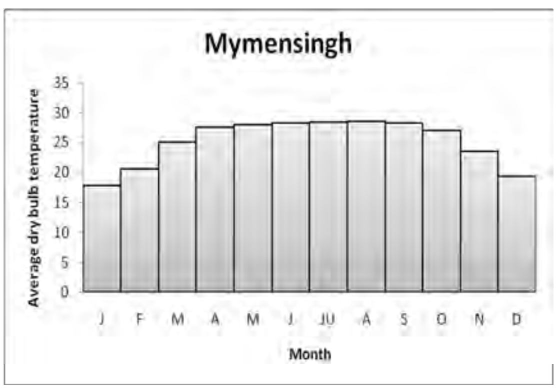
Average dry bulb temperature

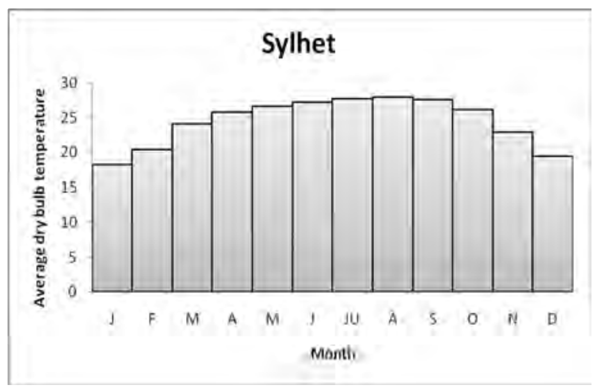


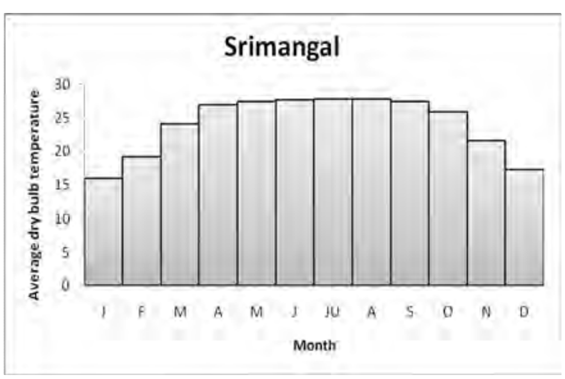


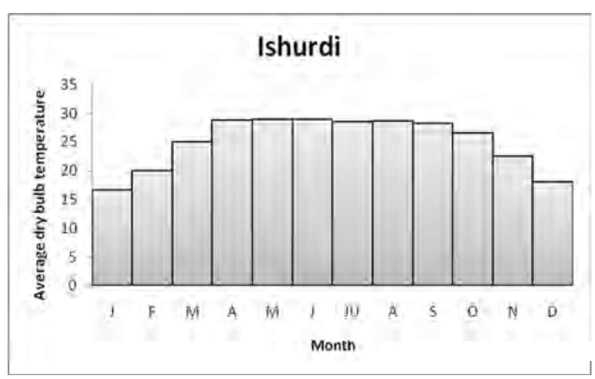


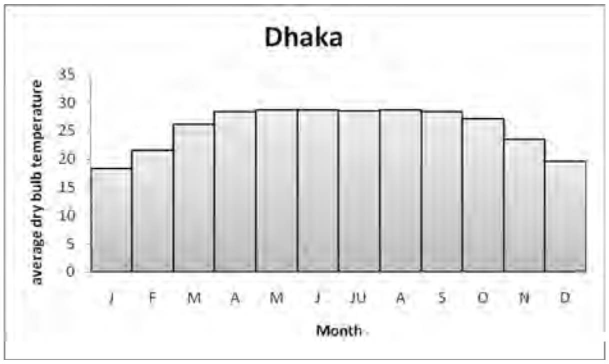
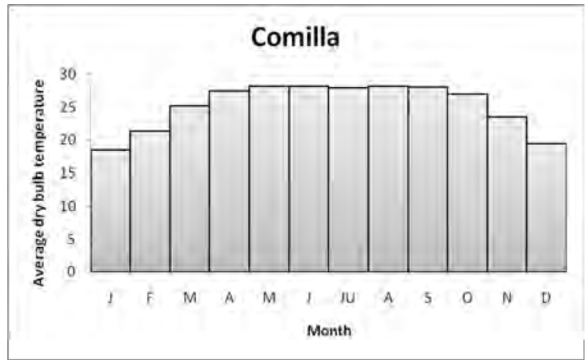
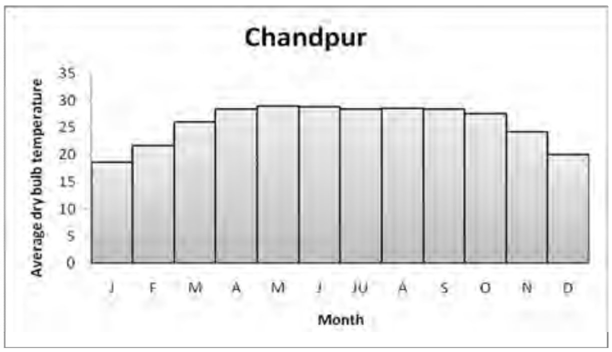
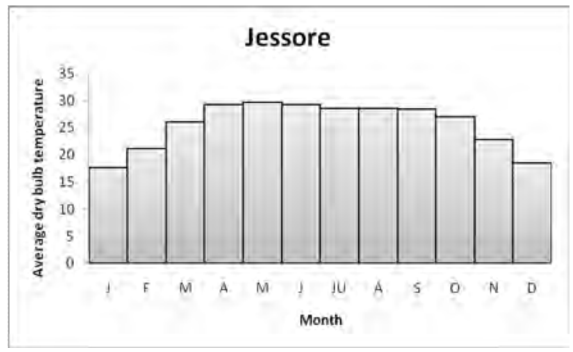
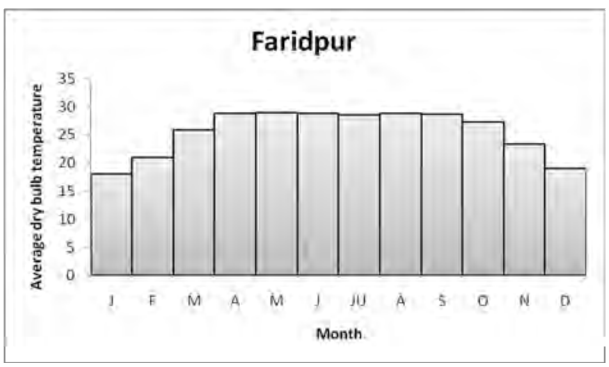
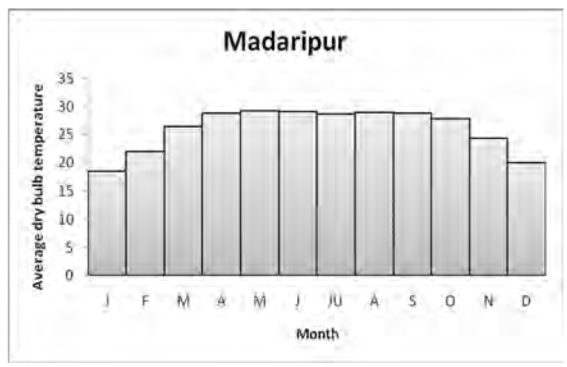
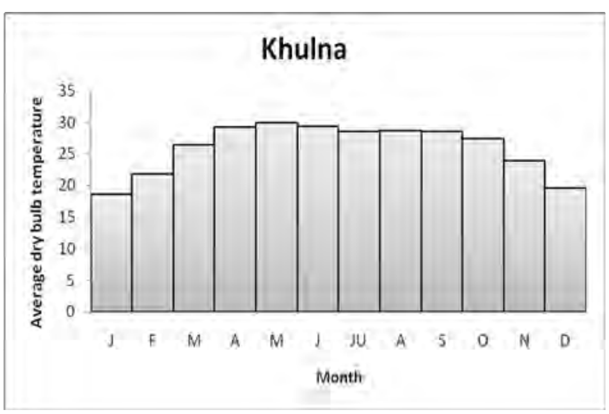
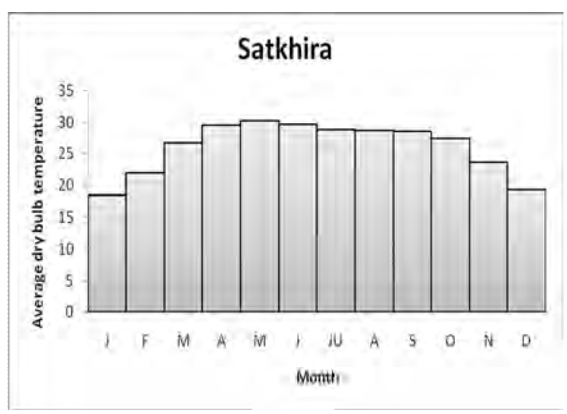


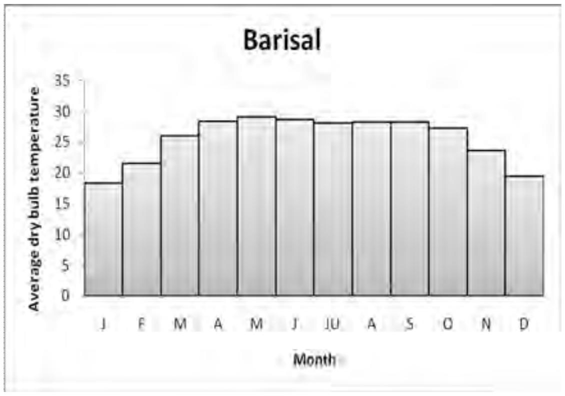


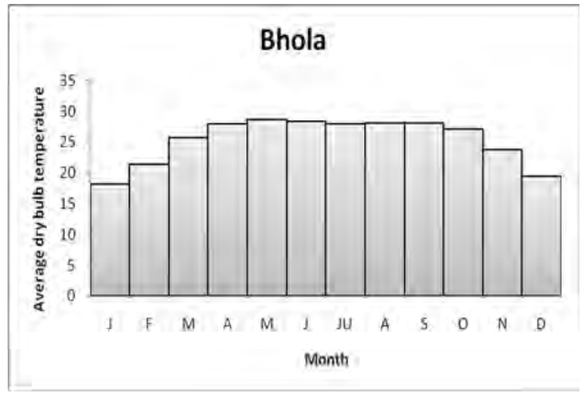


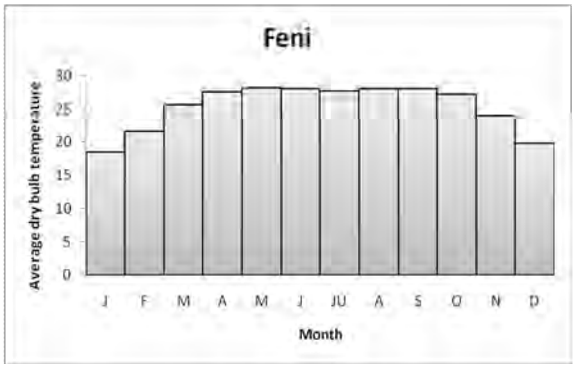


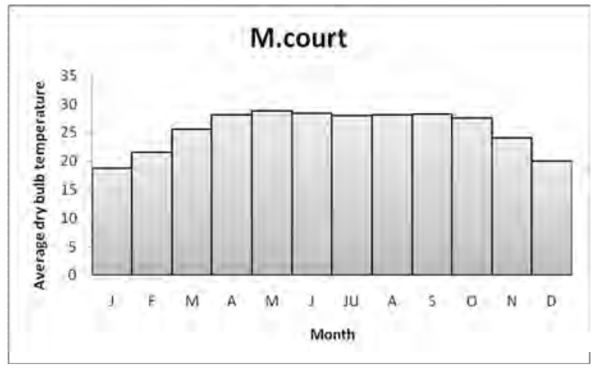


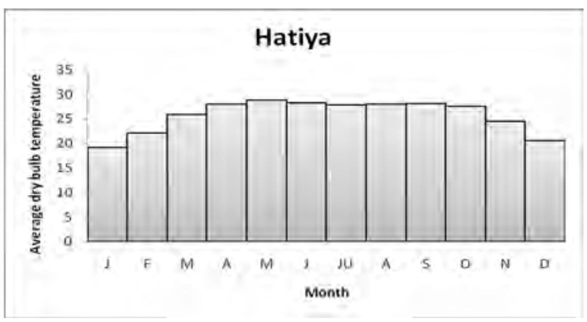

Dhaka
average dry bulb temperature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

Comilla
Average dry bulb temperature
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

Chandpur
Average dry bulb temperature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

Jessore
Average dry bulb temperature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

Faridpur
Average dry bulb temperature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

Madaripur
Average dry bulb temperature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

Khulna
Average dry bulb temperature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

Satkhira
Average dry bulb temperature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

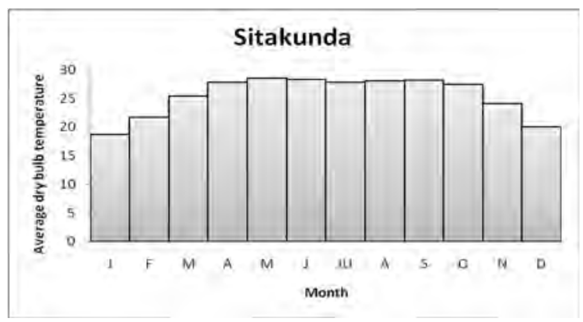

Barisal
Average dry bulb temperature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

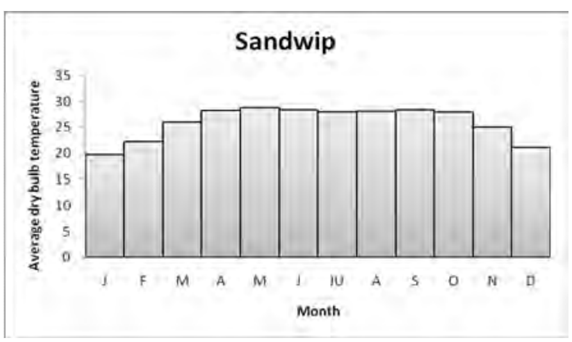

Bhola
Average dry bulb temperature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

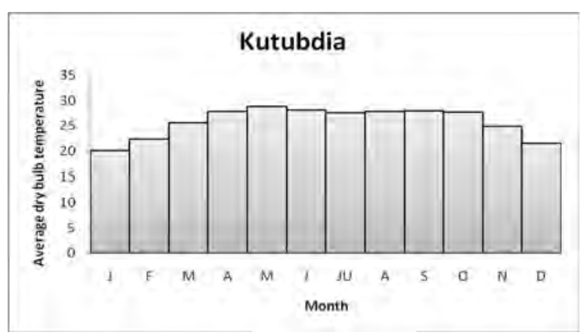

Feni
Average dry bulb temperature
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month


M.court
Average dry bulb temperature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

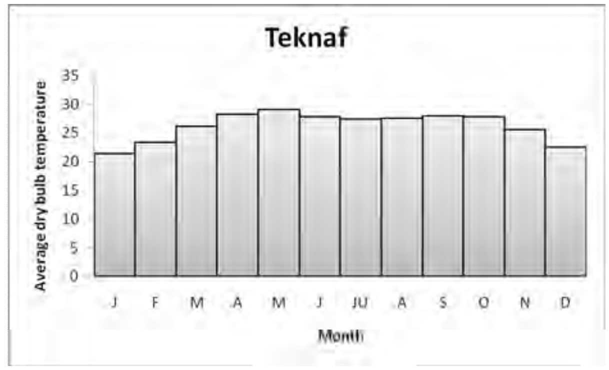

Hatiya
Average dry bulb temperature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

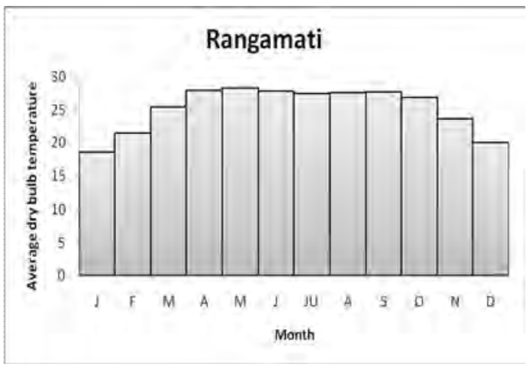

Sitakunda
Average dry bulb temperature
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

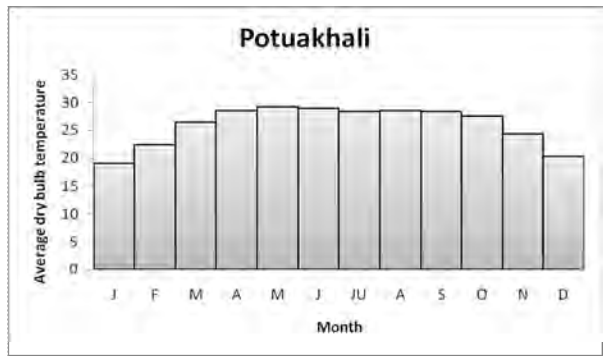

Sandwip
Average dry bulb temperature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

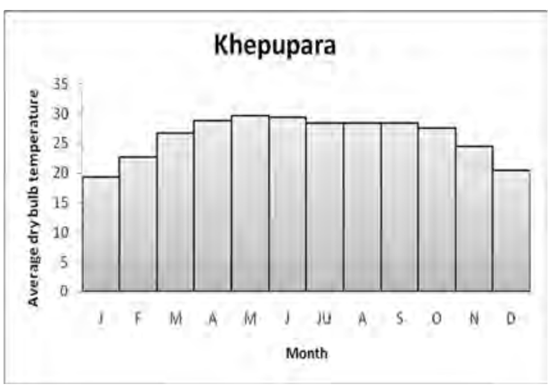

Kutubdia
Average dry bulb temperature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

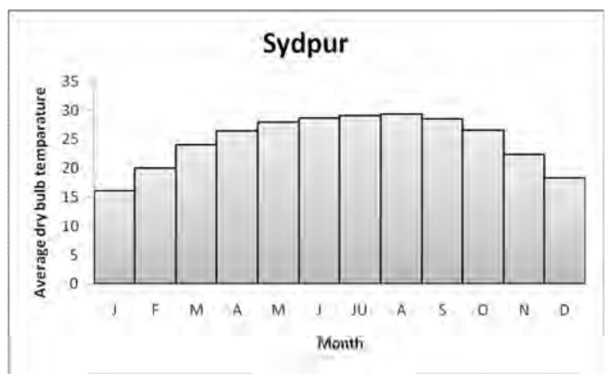

Cox'sbazar
Average dry bulb temperature
0 5 10 15 20 25 30 35
J F M A M J JU A S O N D
Month

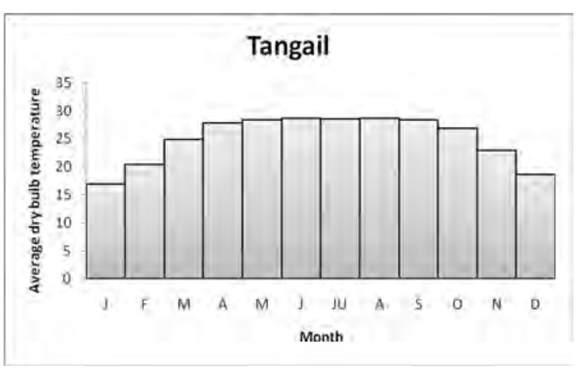

Teknaf
Average dry bulb temperature
0 5 10 15 20 25 30 35
J F M A M J JU A S O N D
Month

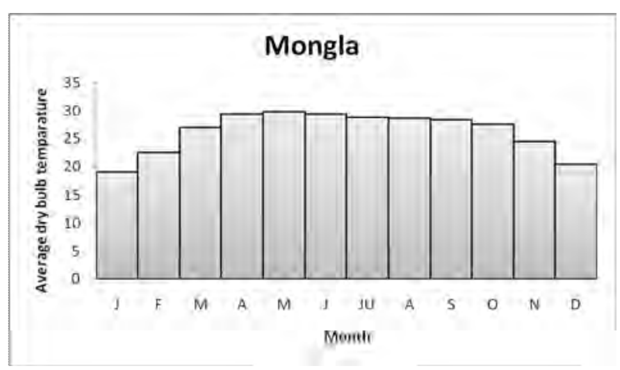

Rangamati
Average dry bulb temperature
0 5 10 15 20 25 30
J F M A M J JU A S O N D
Month

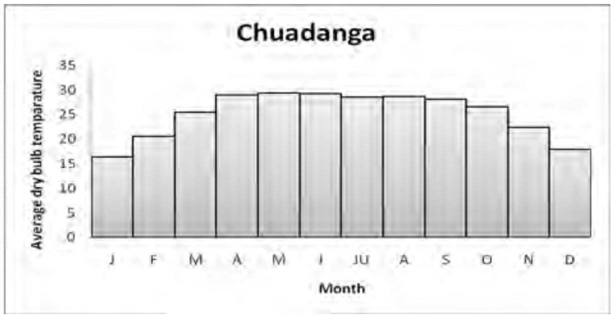

Potuakhali
Average dry bulb temperature
0 5 10 15 20 25 30 35
J F M A M J JU A S O N D
Month


Khepupara
Average dry bulb temperature
0 5 10 15 20 25 30 35
J F M A M J JU A S O N D
Month

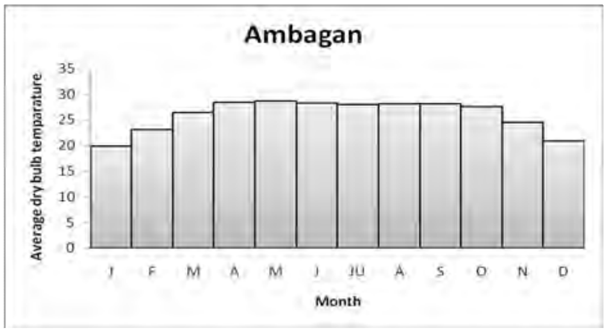

Sydpur
Average dry bulb temparature
0 5 10 15 20 25 30 35
J F M A M J JU A S O N D
Month

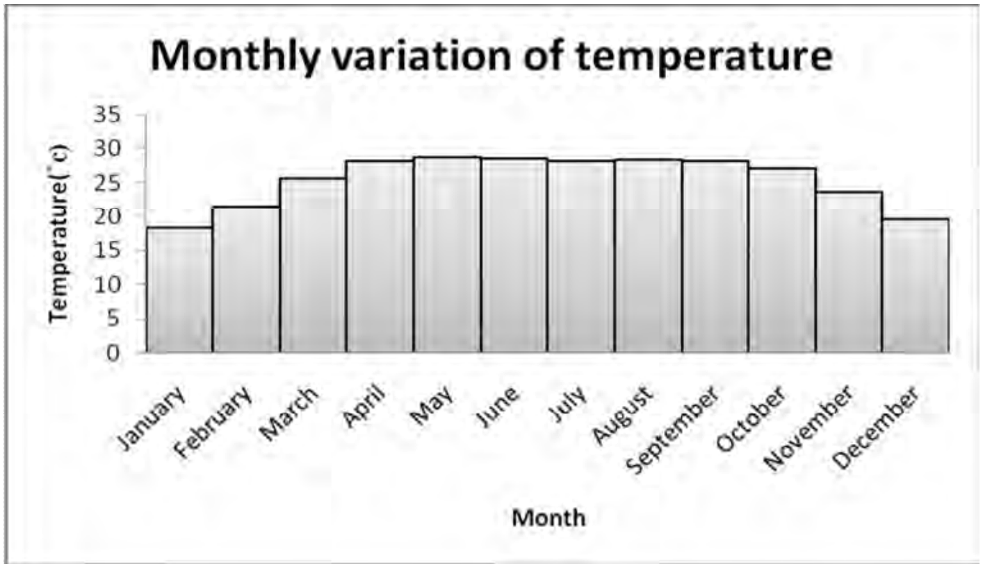

Tangail
Average dry bulb temperature
0 5 10 15 20 25 30 35
J F M A M J JU A S O N D
Month

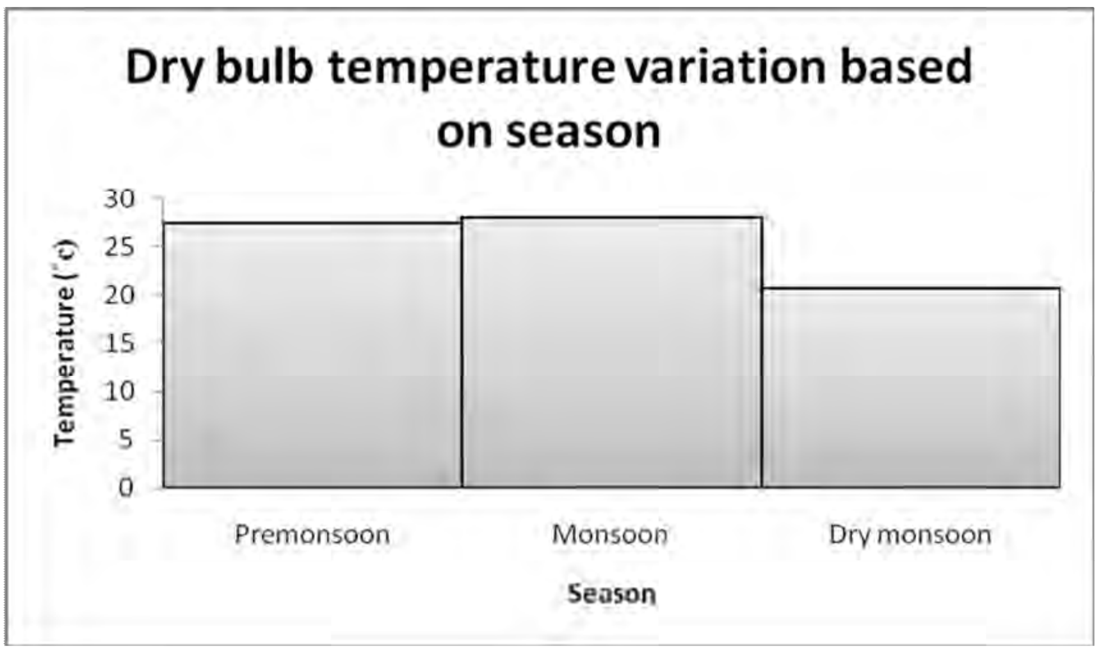

Mongla
Average dry bulb temparature
0 5 10 15 20 25 30 35
J F M A M J JU A S O N D
Month

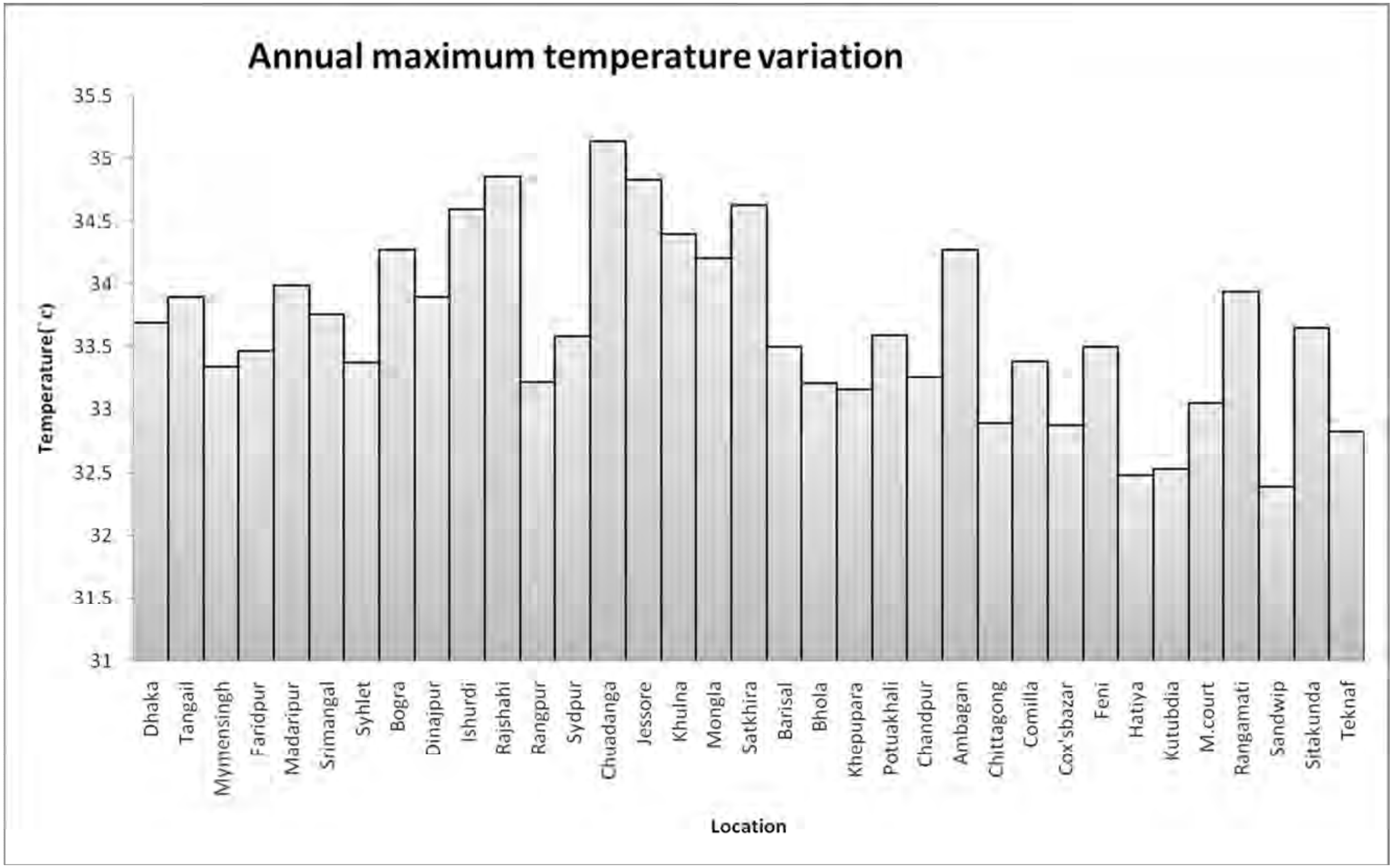

Chuadanga
Average dry bulb temparature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

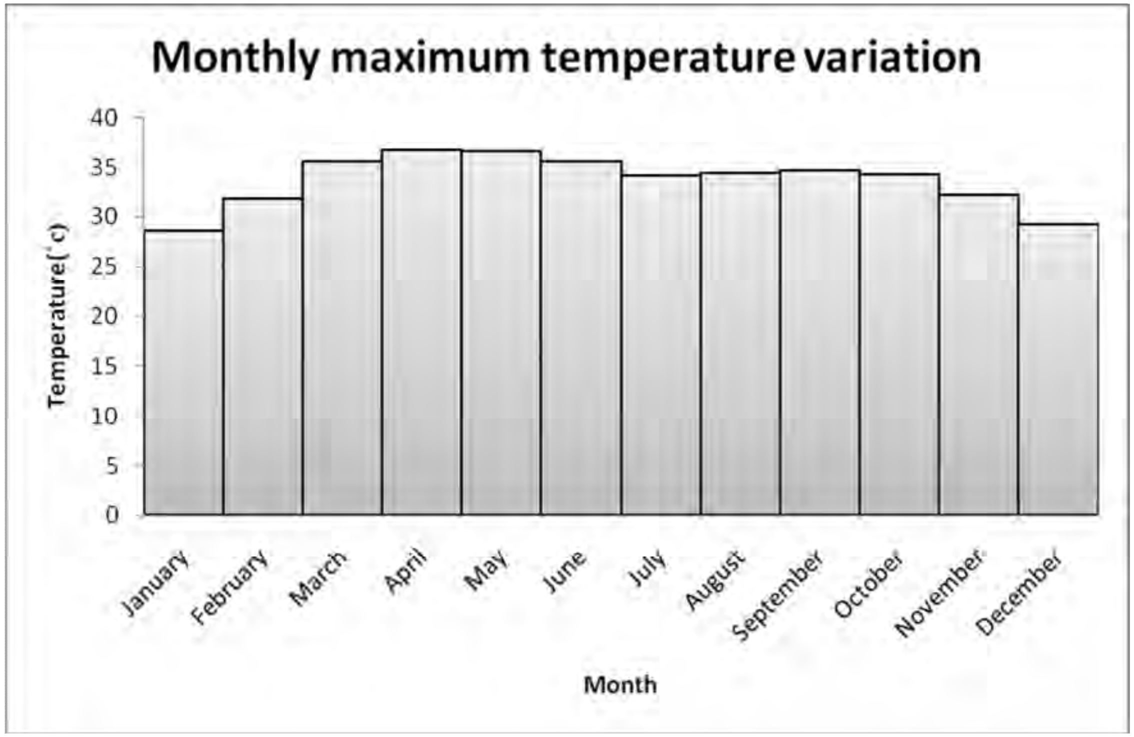

Chittagong
Average dry bulb temparature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

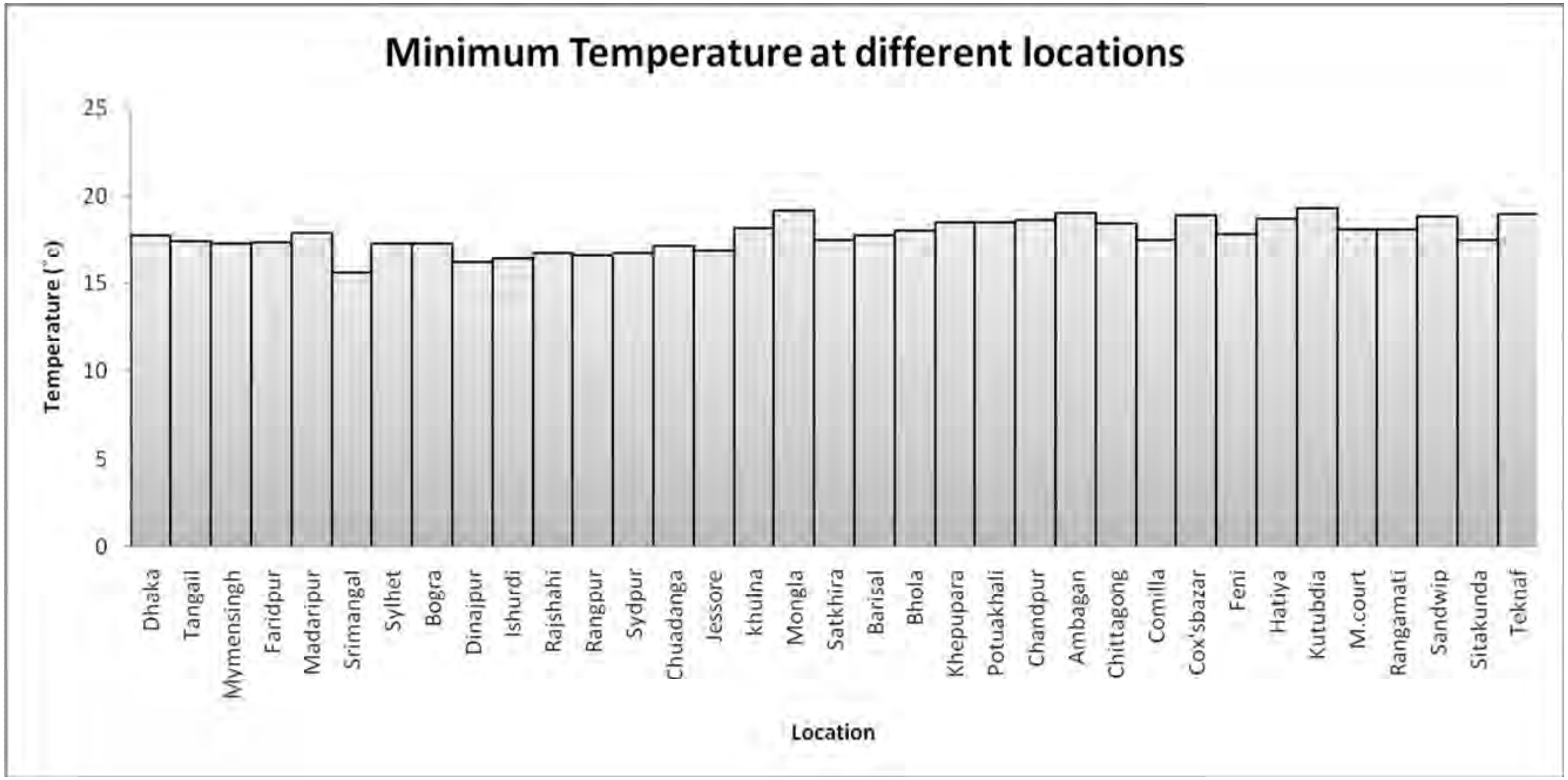

Ambagan
Average dry bulb temparature
35
30
25
20
15
10
5
0
J F M A M J JU A S O N D
Month

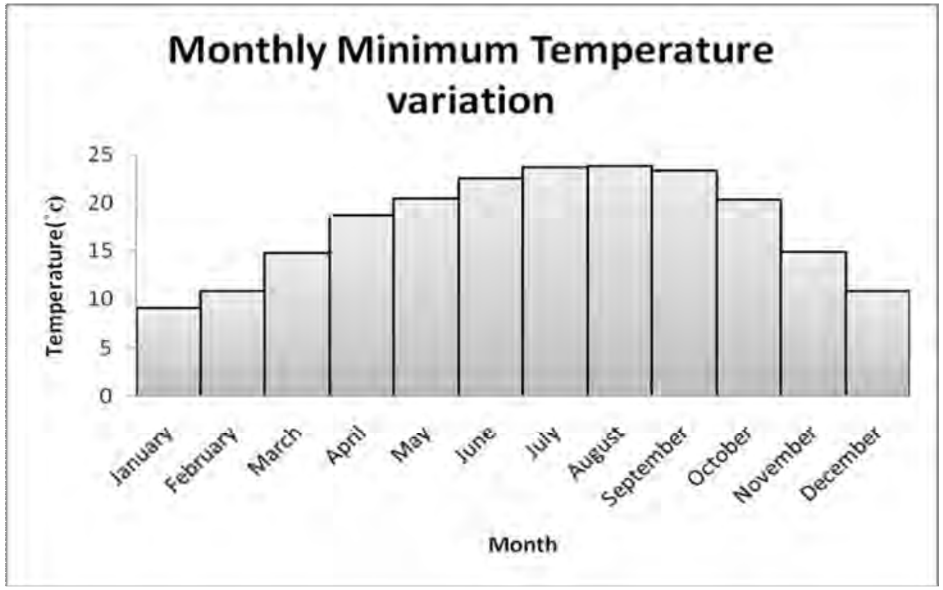

Monthly variation of temperature
35
30
25
20
15
10
5
0
Temperature(˚c)
January
February
March
April
May
June
July
August
September
October
November
December
Month

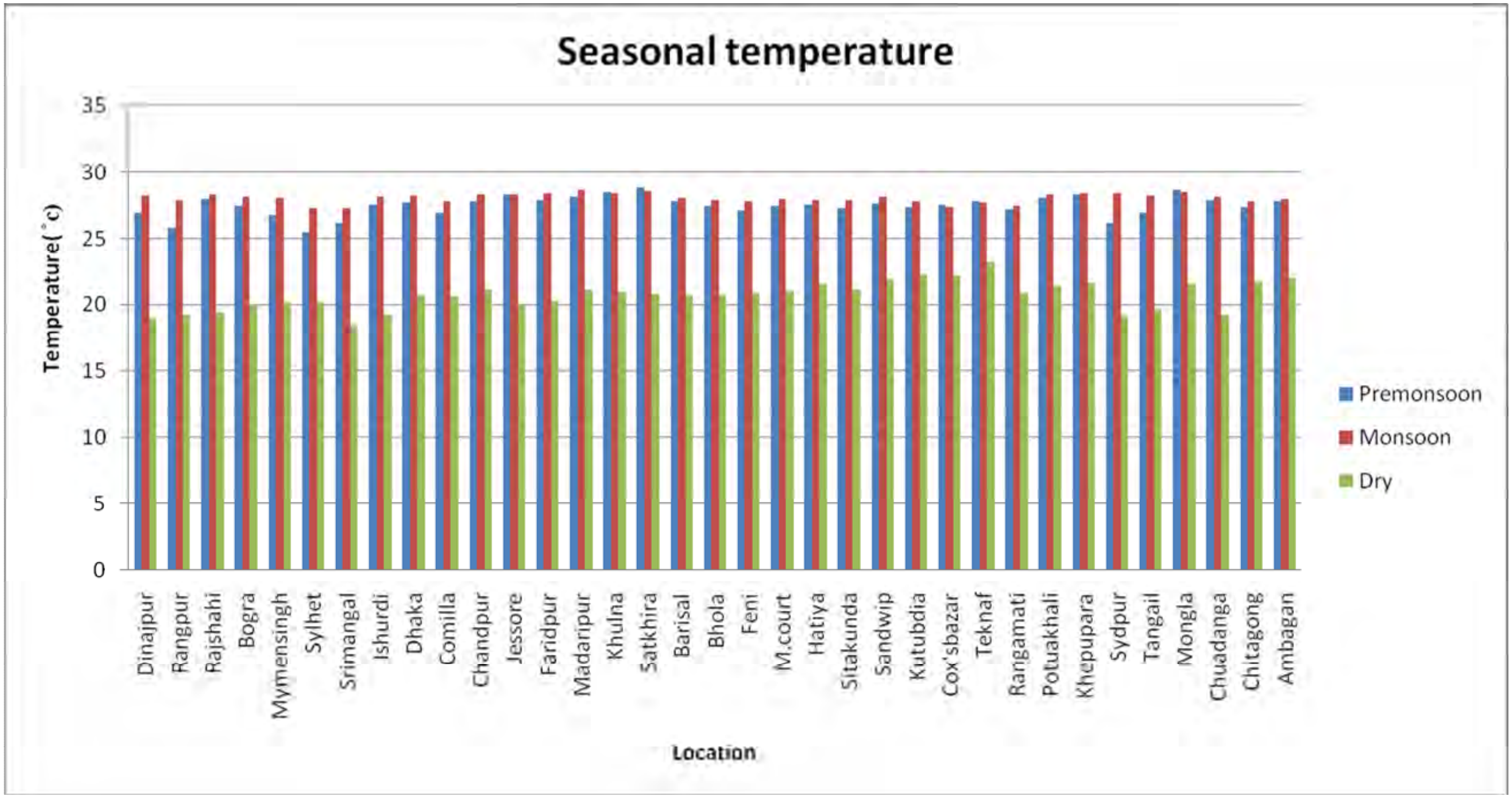

Dry bulb temperature variation based on season
30
25
20
15
10
5
0
Temperature (˚c)
Premonsoon
Monsoon
Dry monsoon
Season

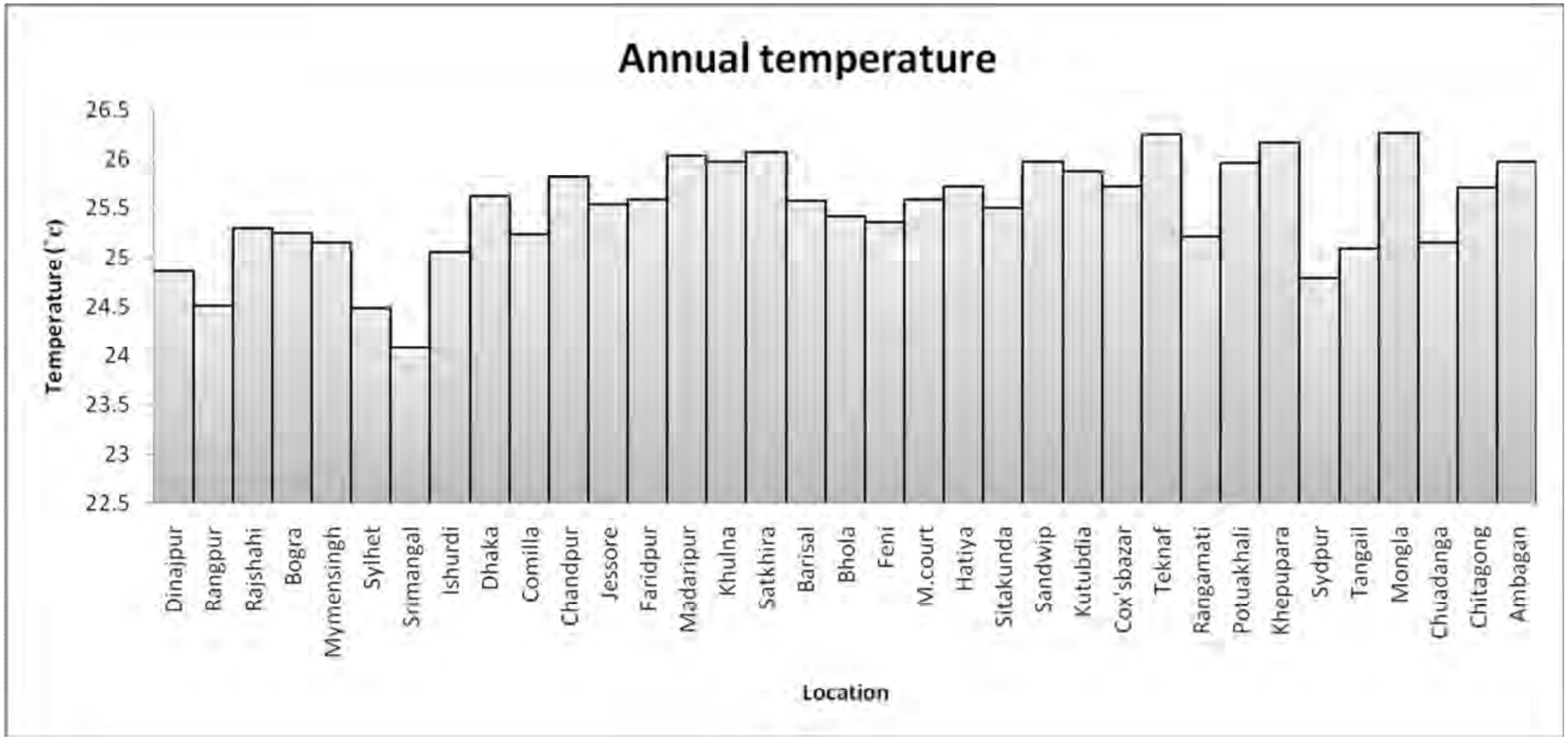

Annual maximum temperature variation
35.5
35
34.5
34
33.5
33
32.5
32
31.5
31
Temperature(°c)
Dhaka
Tangail
Mymensingh
Faridpur
Madaripur
Srimangal
Syhlet
Bogra
Dinajpur
Ishurdi
Rajshahi
Rangpur
Sydpur
Chuadanga
Jessore
Khulna
Mongla
Satkhira
Barisal
Bhola
Khepupara
Potuakhali
Chandpur
Ambagan
Chittagong
Comilla
Cox'sbazar
Feni
Hatiya
Kutubdia
M.court
Rangamati
Sandwip
Sitakunda
Teknaf
Location

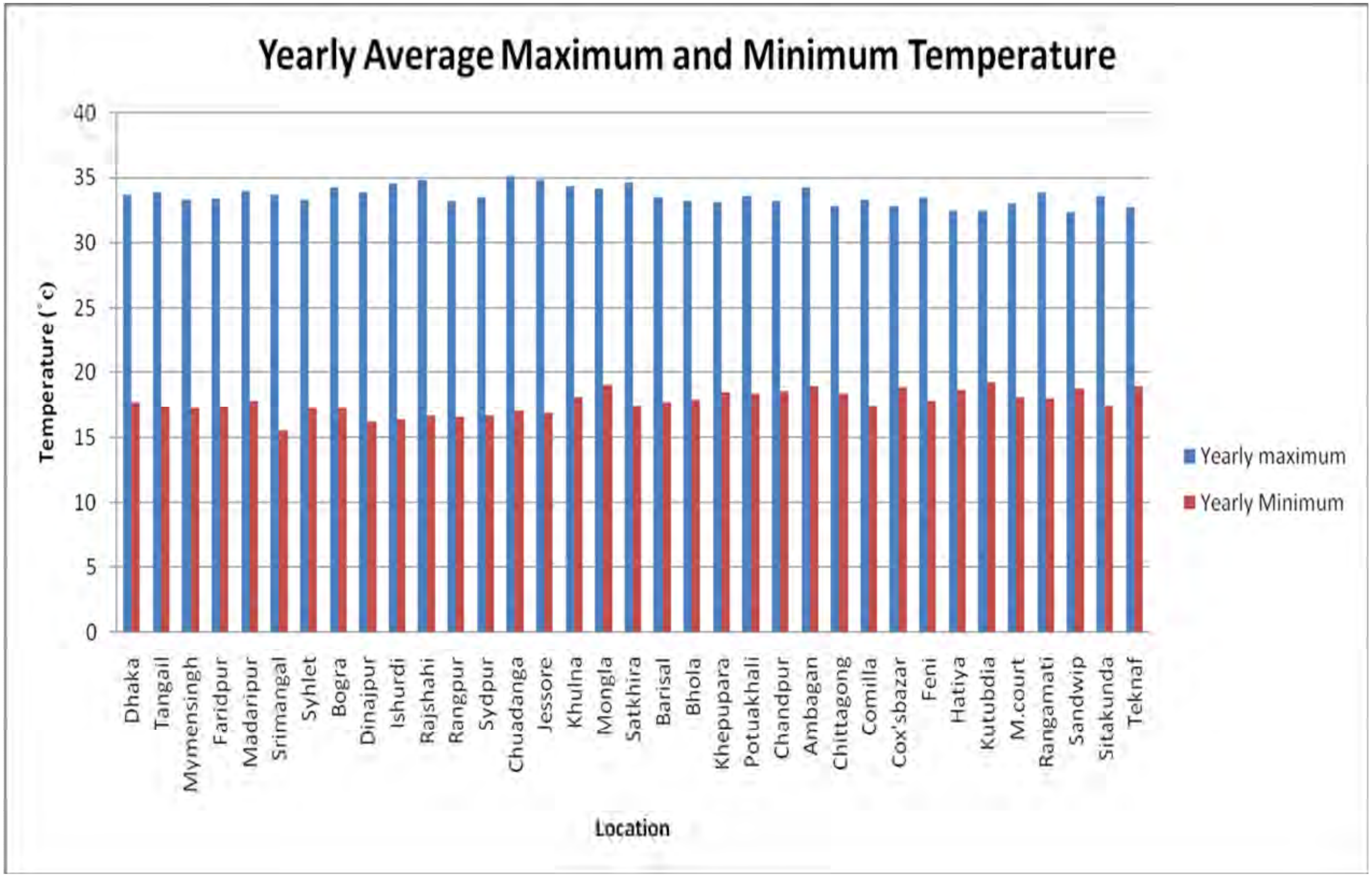

Monthly maximum temperature variation
40
35
30
25
20
15
10
5
0
Temperature(°c)
January
February
March
April
May
June
July
August
September
October
November
December
Month


Minimum Temperature at different locations
Temperature (˚c)
25
20
15
10
5
0
Dhaka
Tangail
Mymensingh
Faridpur
Madaripur
Srimangal
Sylhet
Bogra
Dinajpur
Ishurdi
Rajshahi
Rangpur
Sydpur
Chuadanga
Jessore
khulna
Mongla
Satkhira
Barisal
Bhola
Khepupara
Potuakhali
Chandpur
Ambagan
Chittagong
Comilla
Cox'sbazar
Feni
Hatiya
Kutubdia
M.court
Rangamati
Sandwip
Sitakunda
Teknaf
Location


Monthly Minimum Temperature variation
Temperature(°c)
25
20
15
10
5
0
January
February
March
April
May
June
July
August
September
October
November
December
Month

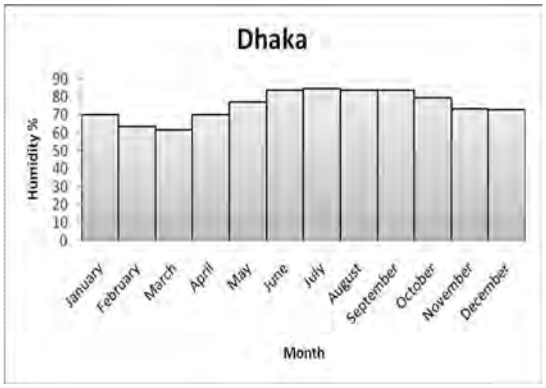

Seasonal temperature
Temperature(˚c)
35
30
25
20
15
10
5
0
Dinajpur
Rangpur
Rajshahi
Bogra
Mymensingh
Sylhet
Srimangal
Ishurdi
Dhaka
Comilla
Chandpur
Jessore
Faridpur
Madaripur
Khulna
Satkhira
Barisal
Bhola
Feni
M.court
Hatiya
Sitakunda
Sandwip
Kutubdia
Cox'sbazar
Teknaf
Rangamati
Potuakhali
Khepupara
Sydpur
Tangail
Mongla
Chuadanga
Chitagong
Ambagan
Location
Premonsoon
Monsoon
Dry

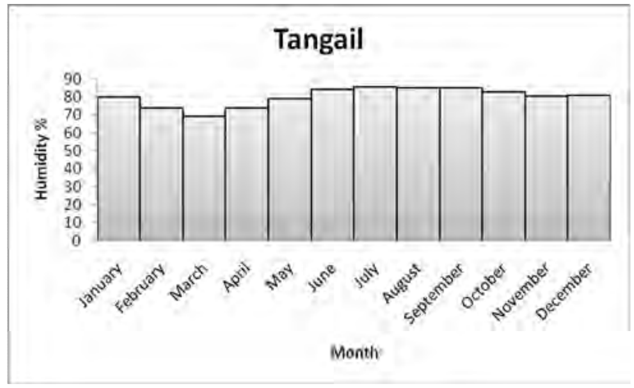

Annual temperature
Temperature (˚c)
26.5
26
25.5
25
24.5
24
23.5
23
22.5
Dinajpur
Rangpur
Rajshahi
Bogra
Mymensingh
Sylhet
Srimangal
Ishurdi
Dhaka
Comilla
Chandpur
Jessore
Faridpur
Madaripur
Khulna
Satkhira
Barisal
Bhola
Feni
M.court
Hatiya
Sitakunda
Sandwip
Kutubdia
Cox'sbazar
Teknaf
Rangamati
Potuakhali
Khepupara
Sydpur
Tangail
Mongla
Chuadanga
Chitagong
Ambagan
Location

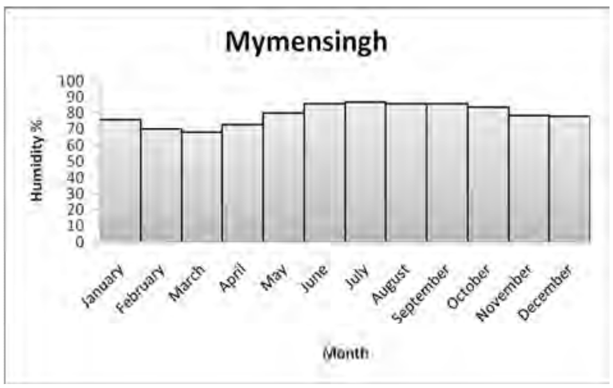


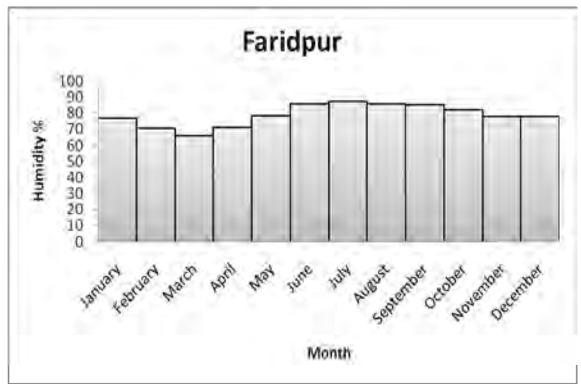
Yearly Average Maximum and Minimum Temperature
Temperature (˚c)
40
35
30
25
20
15
10
5
0
Dhaka
Tangail
Mymensingh
Faridpur
Madaripur
Srimangal
Syhlet
Bogra
Dinajpur
Ishurdi
Rajshahi
Rangpur
Sydpur
Chuadanga
Jessore
Khulna
Mongla
Satkhira
Barisal
Bhola
Khepupara
Potuakhali
Chandpur
Ambagan
Chittagong
Comilla
Cox'sbazar
Feni
Hatiya
Kutubdia
M.court
Rangamati
Sandwip
Sitakunda
Teknaf
Location
Yearly maximum
Yearly Minimum

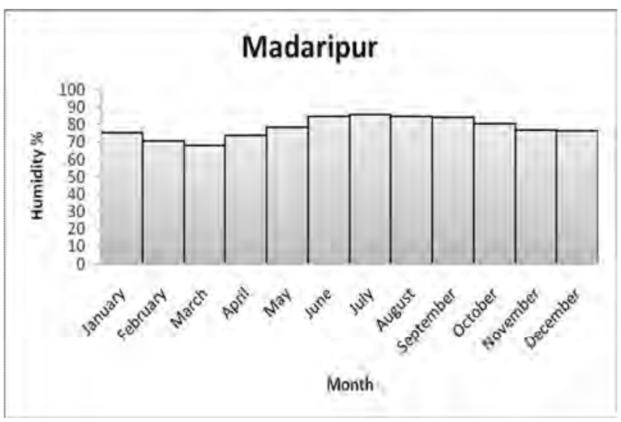
APPENDIX D
TEMPORAL VARIATION AND TREND ANALYSIS OF RELATIVE HUMIDITY

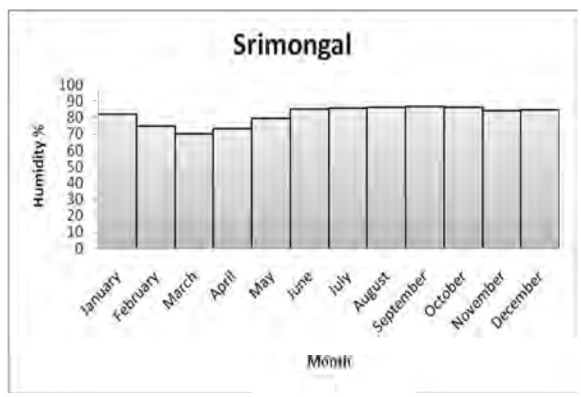

Dhaka
Humidity %
0 10 20 30 40 50 60 70 80 90
January February March April May June July August September October November December
Month

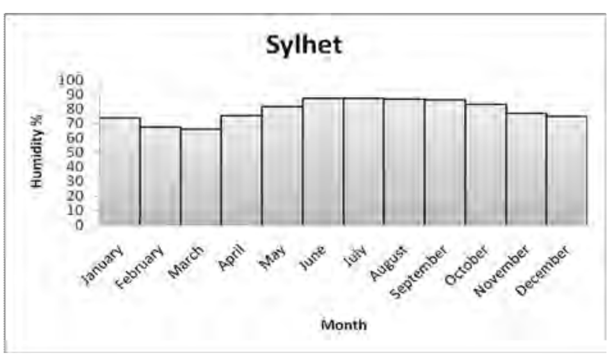

Tangail
Humidity %
0 10 20 30 40 50 60 70 80 90
January February March April May June July August September October November December
Month

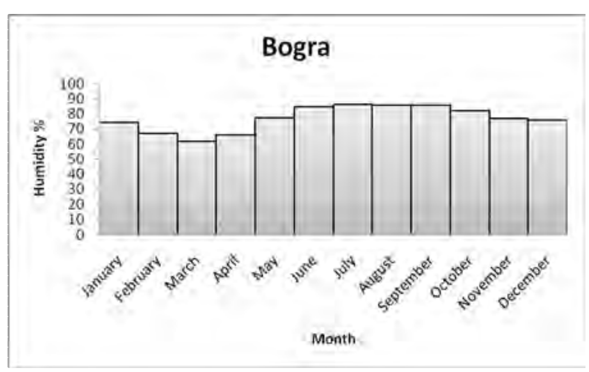

Mymensingh
Humidity %
0 10 20 30 40 50 60 70 80 90 100
January February March April May June July August September October November December
Month

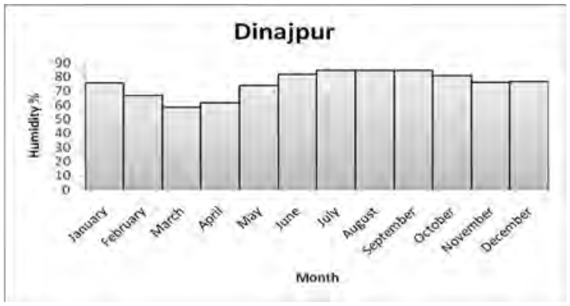

Faridpur
Humidity %
0 10 20 30 40 50 60 70 80 90 100
January February March April May June July August September October November December
Month

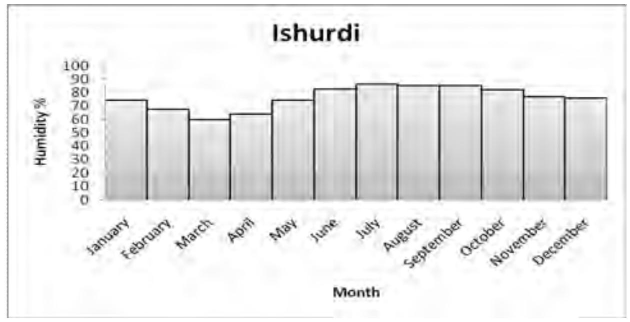

Madaripur
Humidity %
0 10 20 30 40 50 60 70 80 90 100
January February March April May June July August September October November December
Month

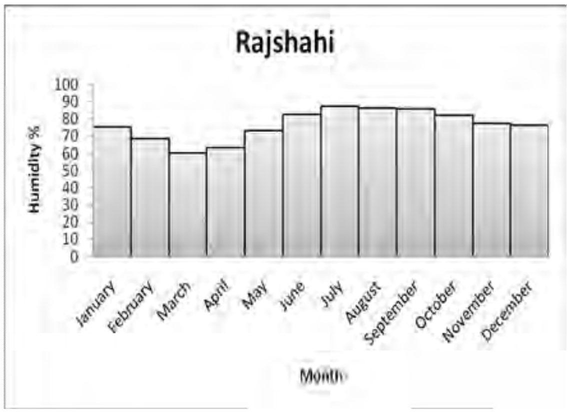

Srimongal
Humidity %
0 10 20 30 40 50 60 70 80 90 100
January February March April May June July August September October November December
Month

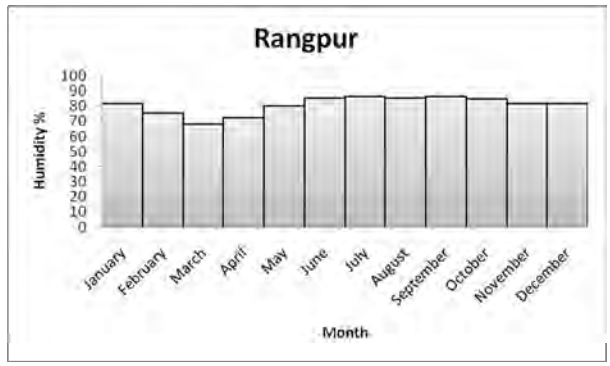

Sylhet
Humidity %
0 10 20 30 40 50 60 70 80 90 100
January February March April May June July August September October November December
Month

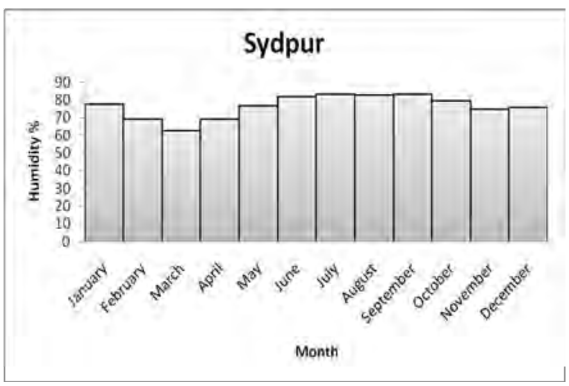

Bogra
Humidity %
0 10 20 30 40 50 60 70 80 90 100
January February March April May June July August September October November December
Month

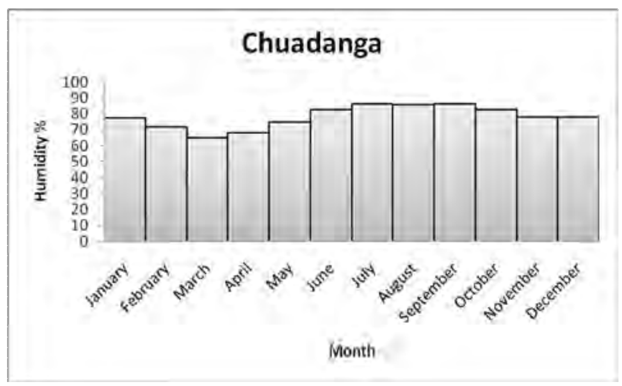

Dinajpur
Humidity %
January February March April May June July August September October November December
Month

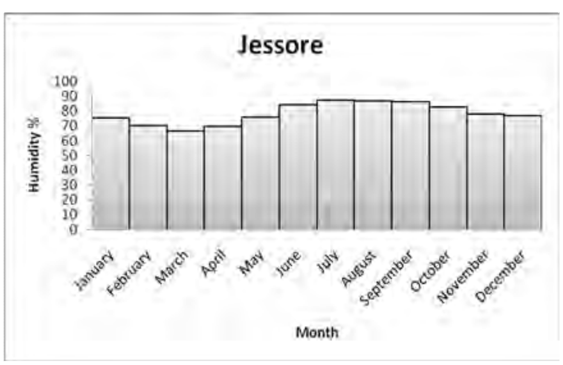

Ishurdi
Humidity %
January February March April May June July August September October November December
Month

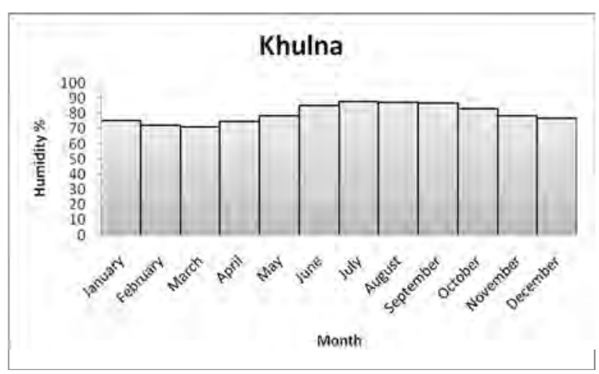

Rajshahi
Humidity %
January February March April May June July August September October November December
Month

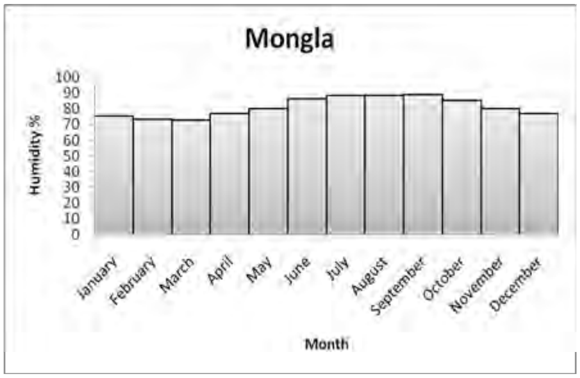

Rangpur
Humidity %
January February March April May June July August September October November December
Month

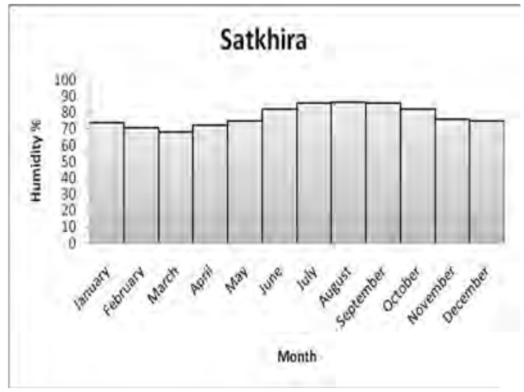

Sydpur
Humidity %
January February March April May June July August September October November December
Month

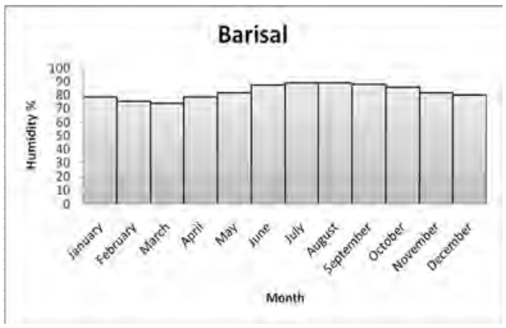

Chuadanga
Humidity %
January February March April May June July August September October November December
Month

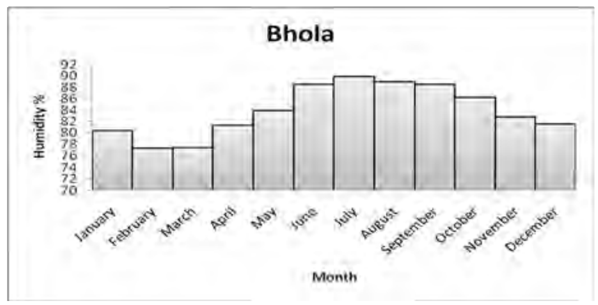

Jessore
Humidity %
January February March April May June July August September October November December
Month

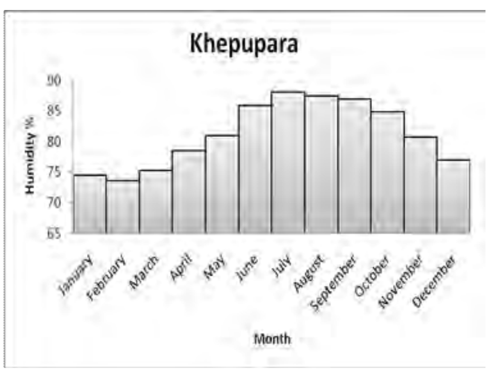

Khulna
Humidity %
January February March April May June July August September October November December
Month

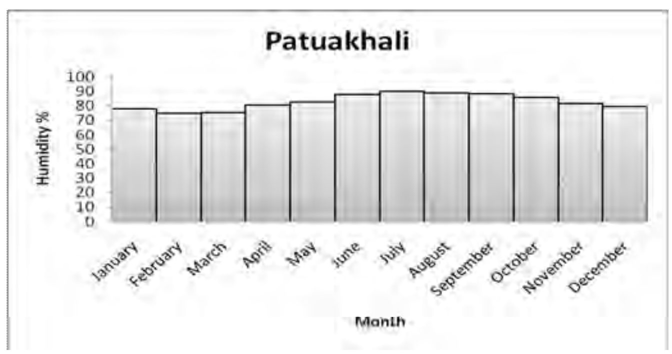

Mongla
Humidity %
100
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
Month

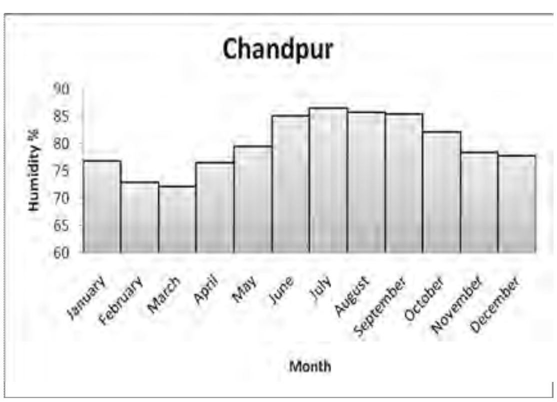

Satkhira
Humidity %
100
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
Month

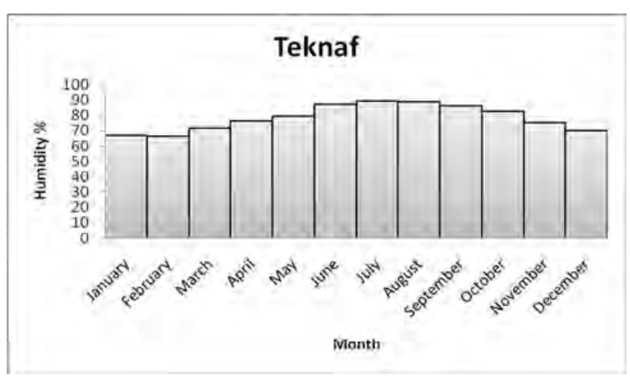

Barisal
Humidity %
100
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
Month

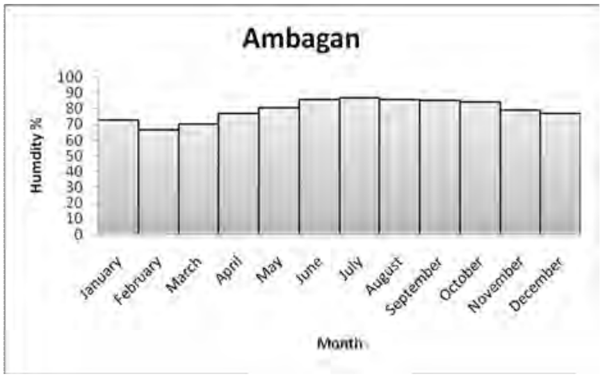

Bhola
Humidity %
92
90
88
86
84
82
80
78
76
74
72
70
January
February
March
April
May
June
July
August
September
October
November
December
Month

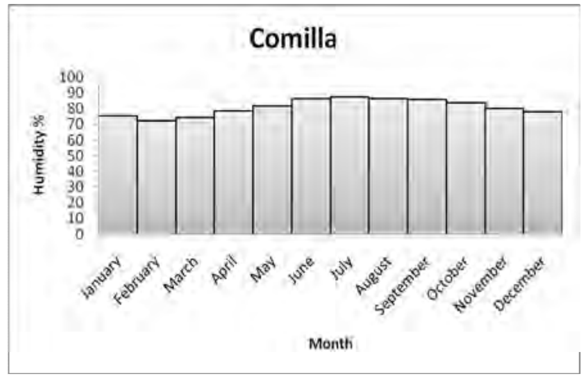

Khepupara
Humidity %
90
85
80
75
70
65
January
February
March
April
May
June
July
August
September
October
November
December
Month

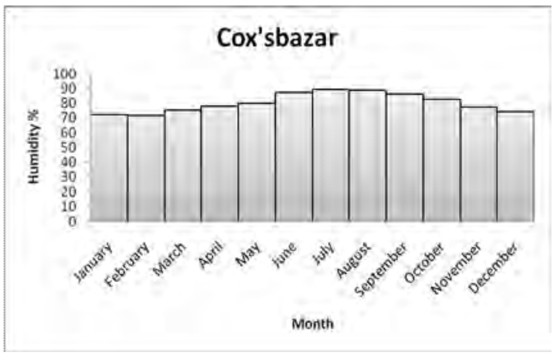

Patuakhali
Humidity %
100
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
Month

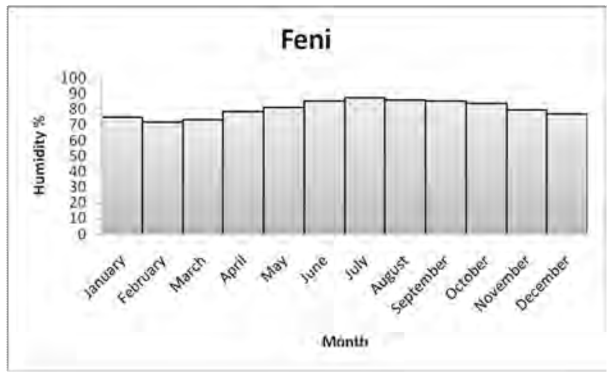

Chandpur
Humidity %
90
85
80
75
70
65
60
January
February
March
April
May
June
July
August
September
October
November
December
Month

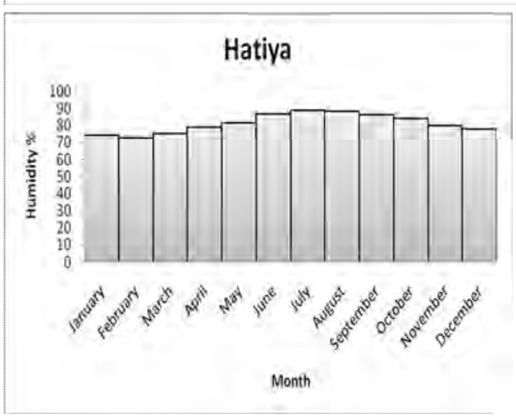

Teknaf
Humidity %
100
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
Month

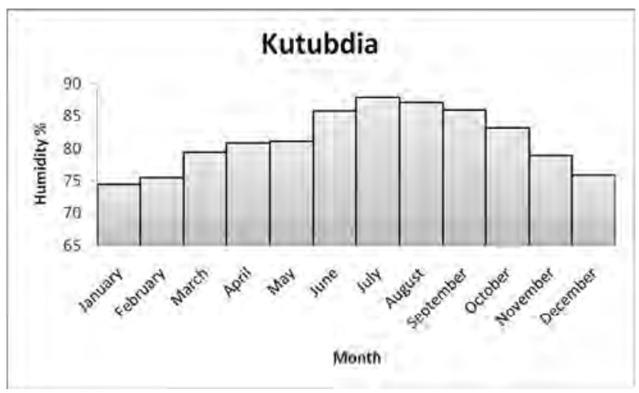

Ambagan
Humidity %
100
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
Month

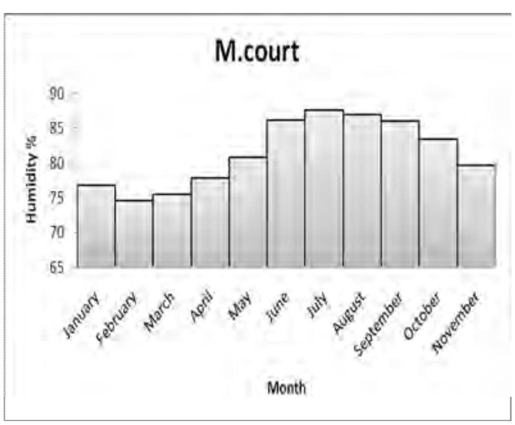

Comilla
Humidity %
100
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
Month

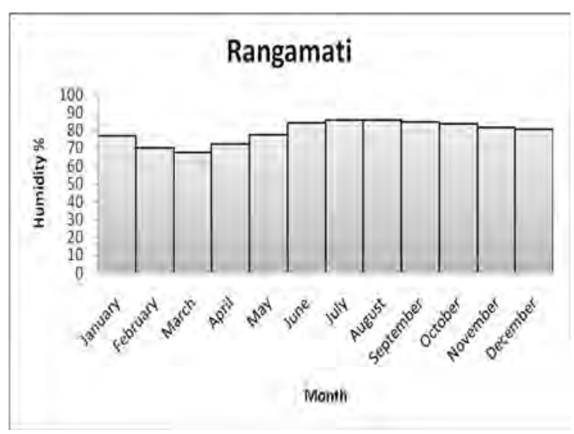

Cox'sbazar
Humidity %
100
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
Month

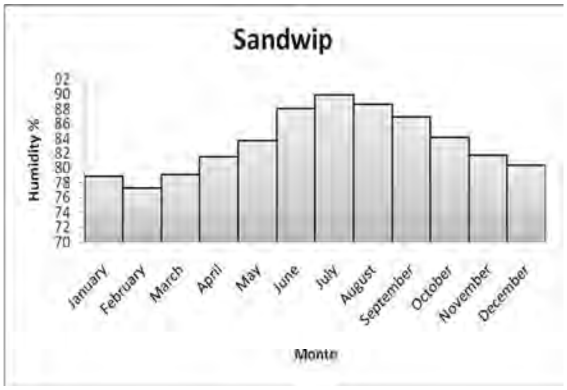

Feni
Humidity %
100
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
Month


Hatiya
Humidity %
100
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
Month

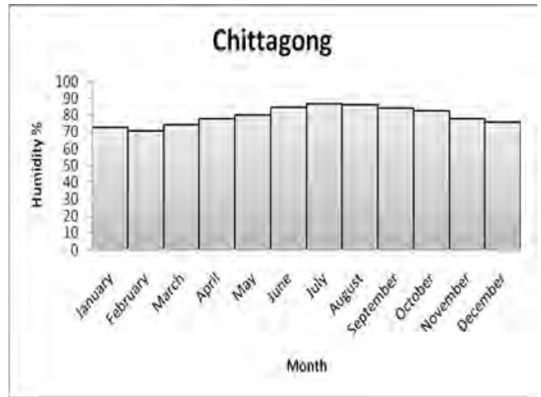

Kutubdia
Humidity %
90
85
80
75
70
65
January
February
March
April
May
June
July
August
September
October
November
December
Month


M.court
Humidity %
90
85
80
75
70
65
January
February
March
April
May
June
July
August
September
October
November
Month


Rangamati
Humidity %
100
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
Month

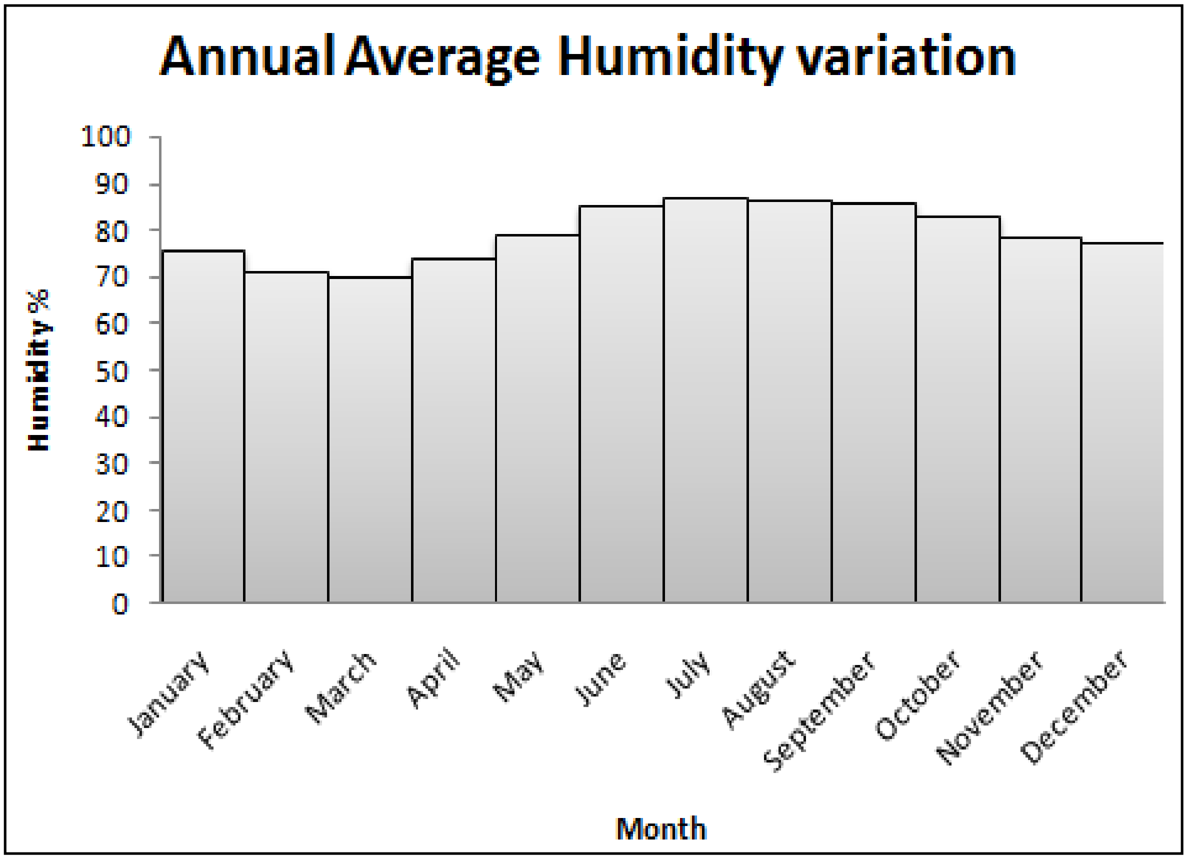


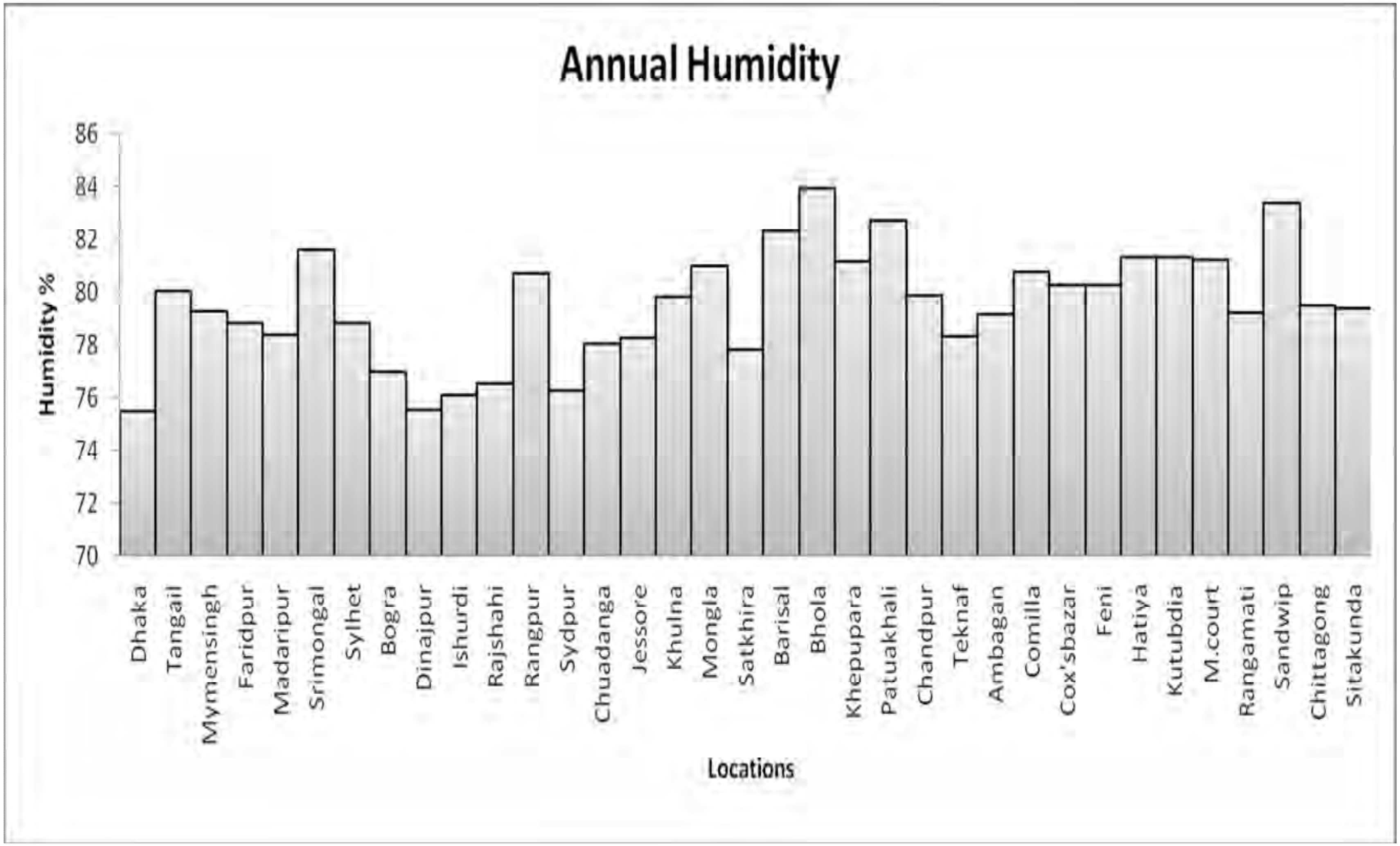
Sandwip
Humidity %
Month

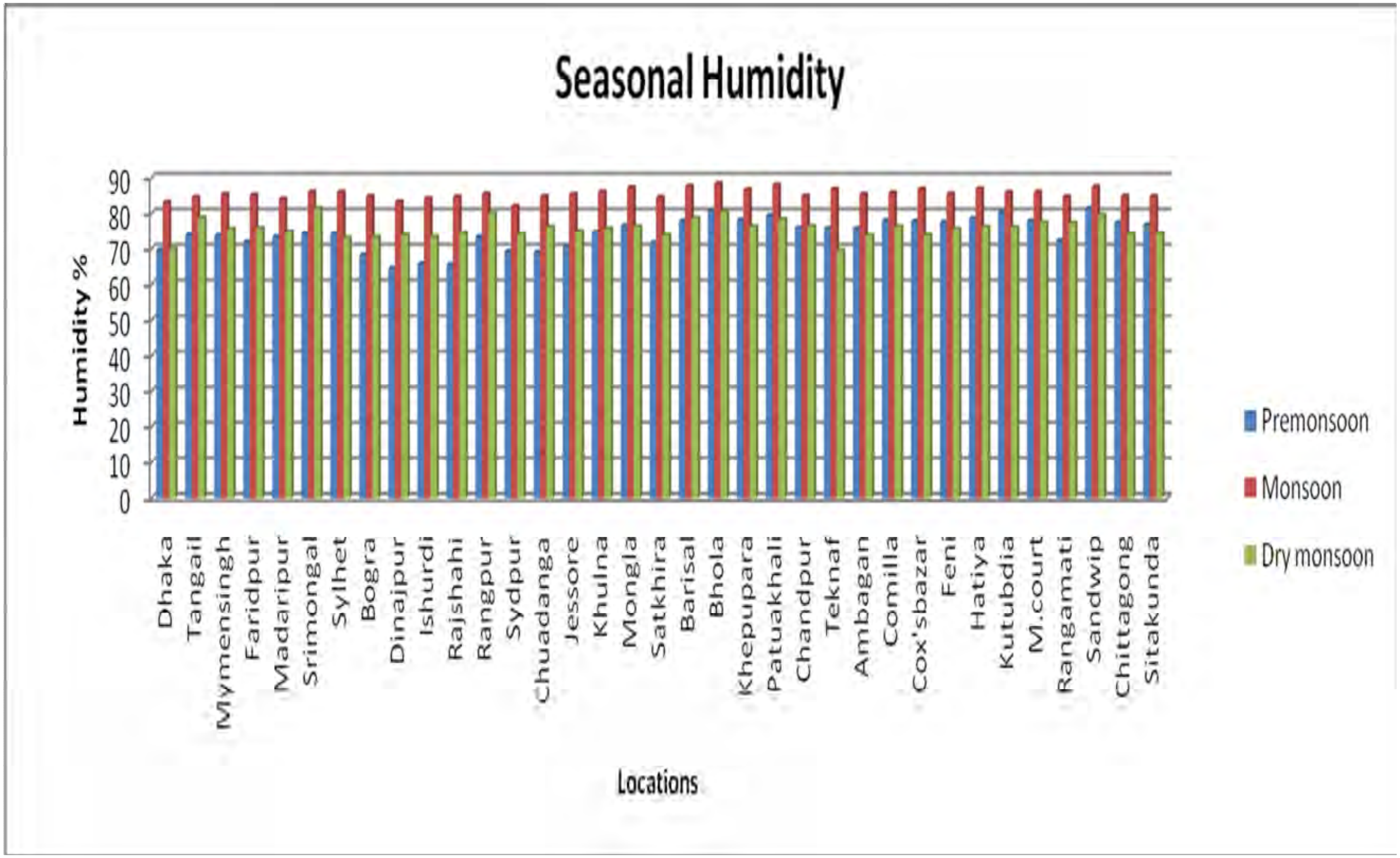


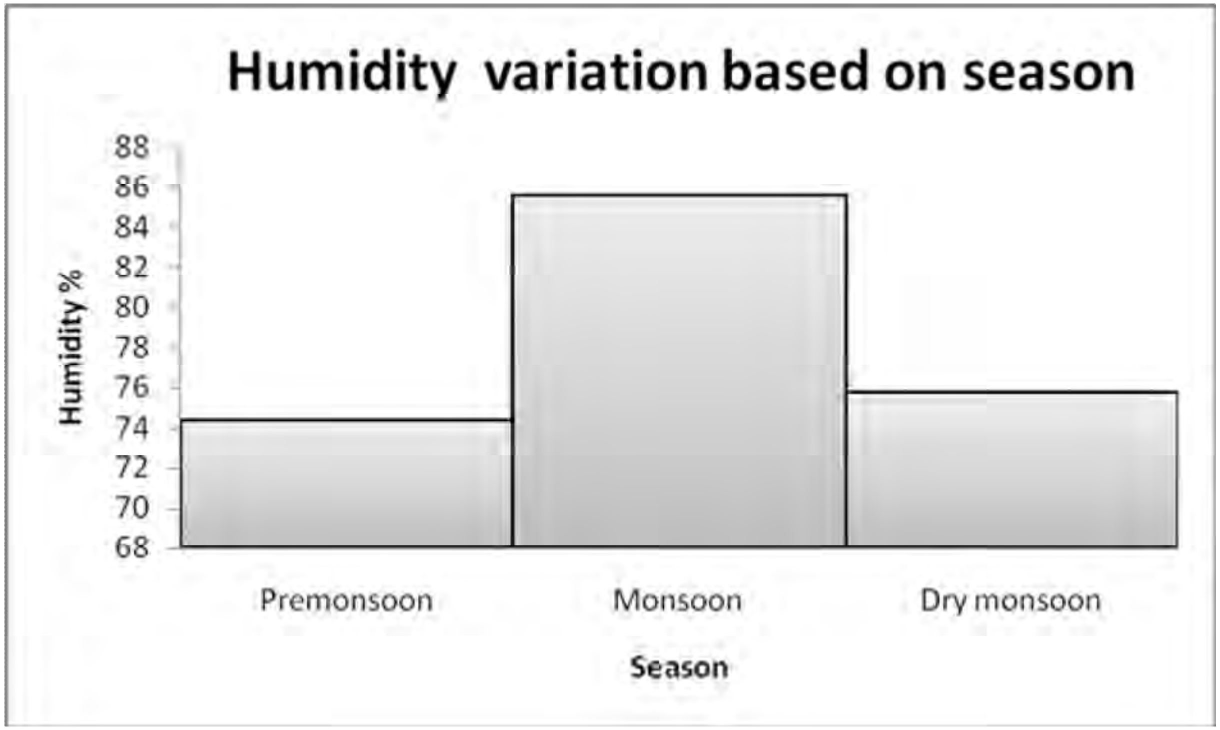
Chittagong
Humidity %
Month

Sitakunda
Humidity %
Month

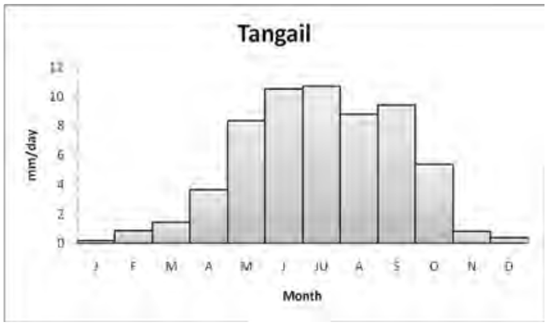

Annual Average Humidity variation
100
90
80
70
60
50
40
30
20
10
0
Humidity %
January
February
March
April
May
June
July
August
September
October
November
December
Month

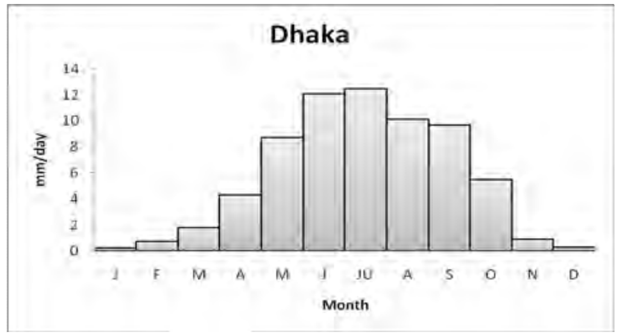

Annual Humidity
Humidity %
86
84
82
80
78
76
74
72
70
Dhaka
Tangail
Mymensingh
Faridpur
Madaripur
Srimongal
Sylhet
Bogra
Dinajpur
Ishurdi
Rajshahi
Rangpur
Sydpur
Chuadanga
Jessore
Khulna
Mongla
Satkhira
Barisal
Bhola
Khepupara
Patuakhali
Chandpur
Teknaf
Ambagan
Comilla
Cox'sbazar
Feni
Hatiya
Kutubdia
M.court
Rangamati
Sandwip
Chittagong
Sitakunda
Locations

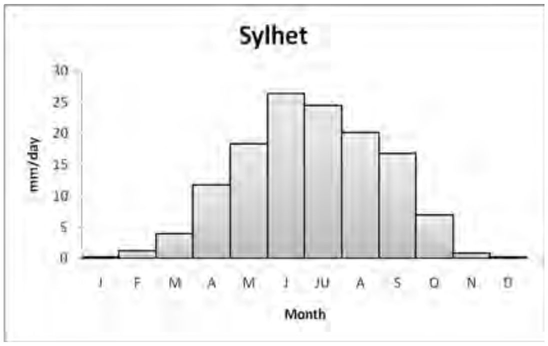

Seasonal Humidity
Humidity %
90
80
70
60
50
40
30
20
10
0
Dhaka
Tangail
Mymensingh
Faridpur
Madaripur
Srimongal
Sylhet
Bogra
Dinajpur
Ishurdi
Rajshahi
Rangpur
Sydpur
Chuadanga
Jessore
Khulna
Mongla
Satkhira
Barisal
Bhola
Khepupara
Patuakhali
Chandpur
Teknaf
Ambagan
Comilla
Cox'sbazar
Feni
Hatiya
Kutubdia
M.court
Rangamati
Sandwip
Chittagong
Sitakunda
Locations
Premonsoon
Monsoon
Dry monsoon

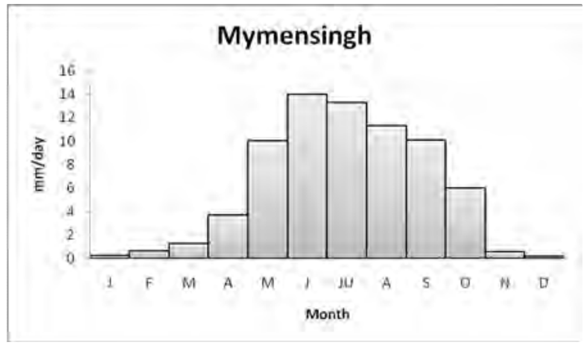

Humidity variation based on season
Humidity %
88
86
84
82
80
78
76
74
72
70
68
Premonsoon
Monsoon
Dry monsoon
Season

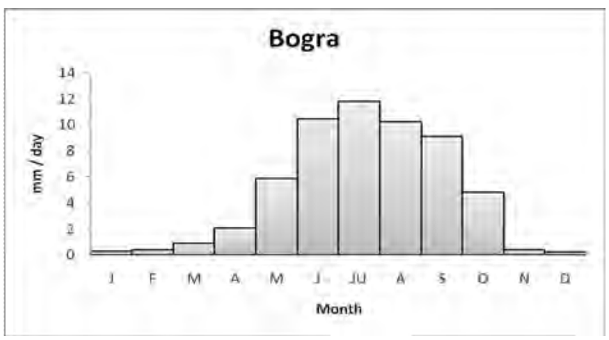
APPENDIX E
TEMPORAL VARIATION AND TREND ANALYSIS OF RAINFALL

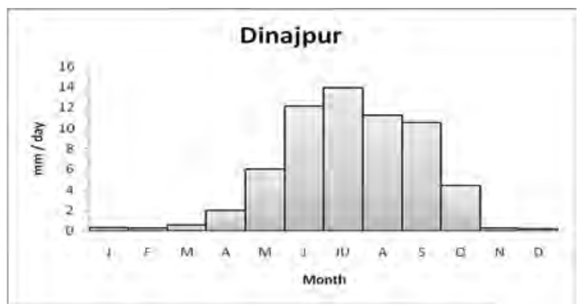

Tangail
mm/day
0 2 4 6 8 10 12
J F M A M J JU A S O N D
Month

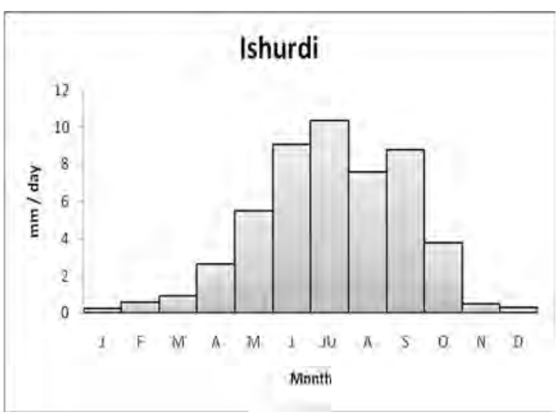

Dhaka
mm/day
0 2 4 6 8 10 12 14
J F M A M J JU A S O N D
Month

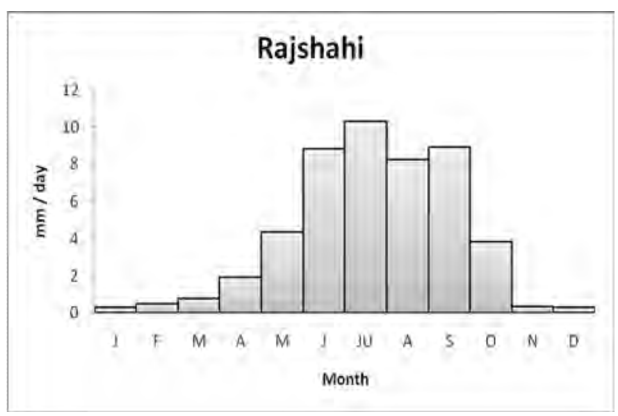

Sylhet
mm/day
0 5 10 15 20 25 30
J F M A M J JU A S O N D
Month

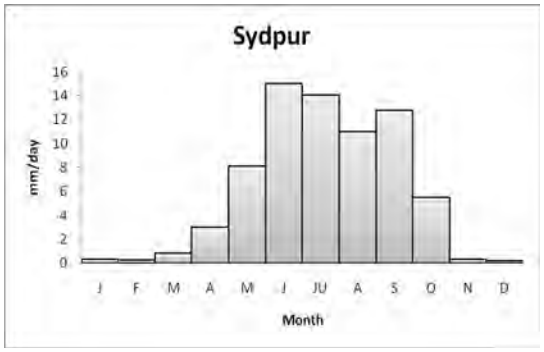

Mymensingh
mm/day
0 2 4 6 8 10 12 14 16
J F M A M J JU A S O N D
Month

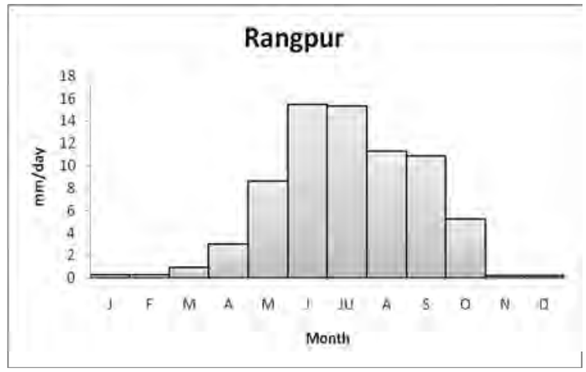

Bogra
mm / day
0 2 4 6 8 10 12 14
J F M A M J JU A S O N D
Month

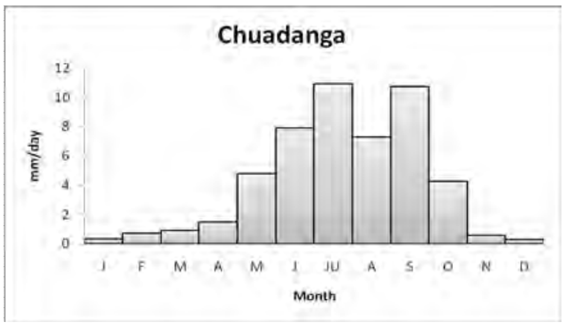

Dinajpur
mm / day
0 2 4 6 8 10 12 14 16
J F M A M J JU A S O N D
Month


Ishurdi
mm / day
0 2 4 6 8 10 12
J F M A M J JU A S O N D
Month

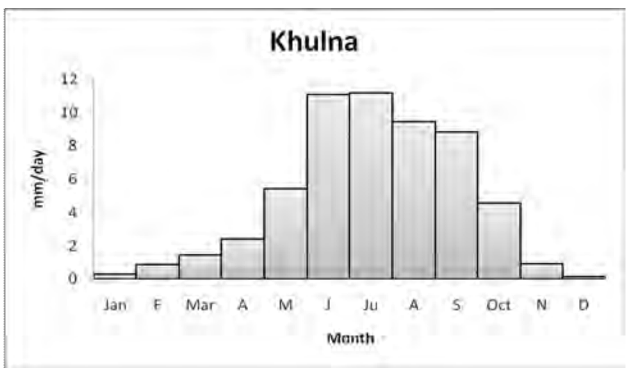

Rajshahi
mm / day
0 2 4 6 8 10 12
J F M A M J JU A S O N D
Month

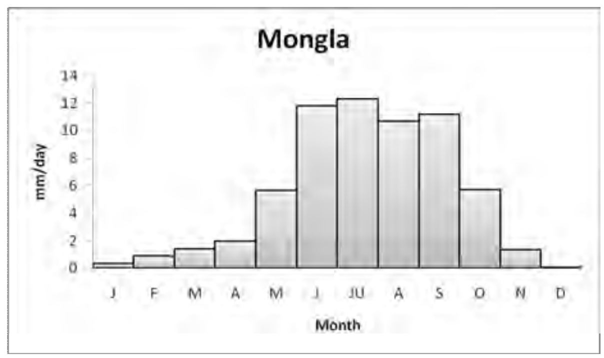

Sydpur
mm/day
Month
J F M A M J JU A S O N D

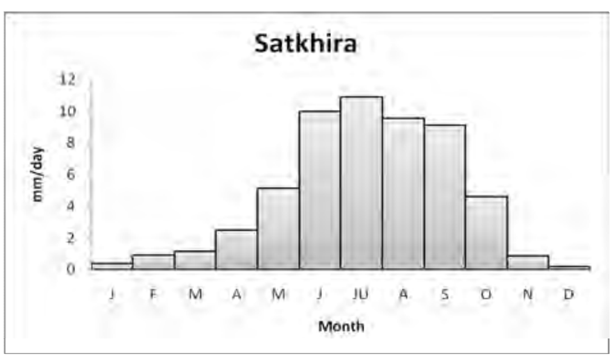

Rangpur
mm/day
Month

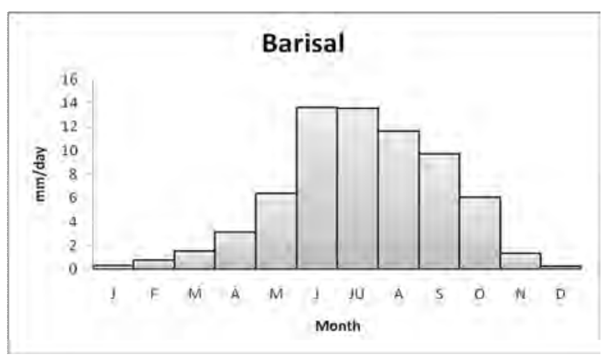

Chuadanga
mm/day
Month

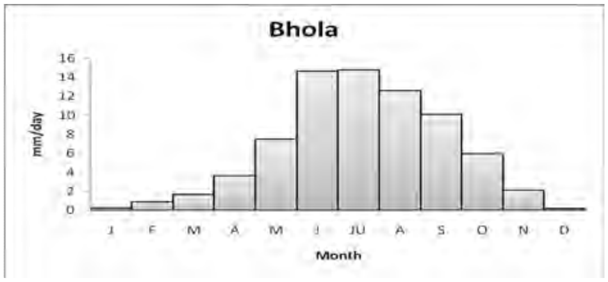

Jessore
mm/day
Month

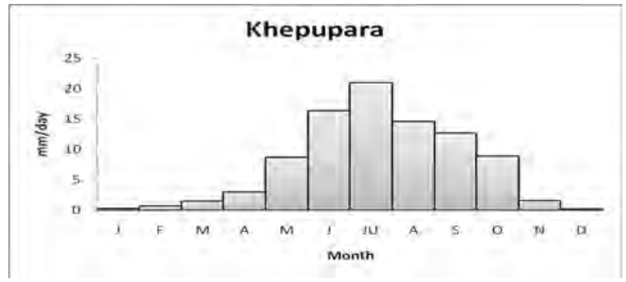

Khulna
mm/day
Month
Jan F Mar A M J Ju A S Oct N D

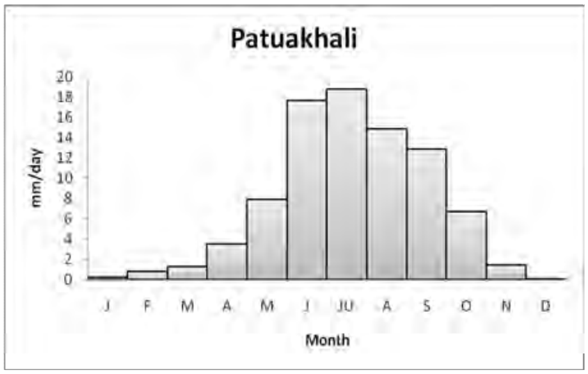

Mongla
mm/day
Month

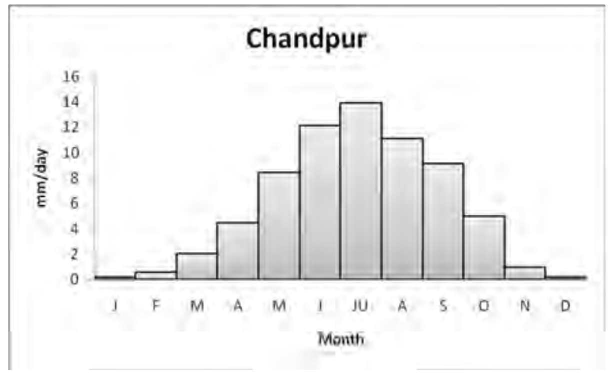

Satkhira
mm/day
Month

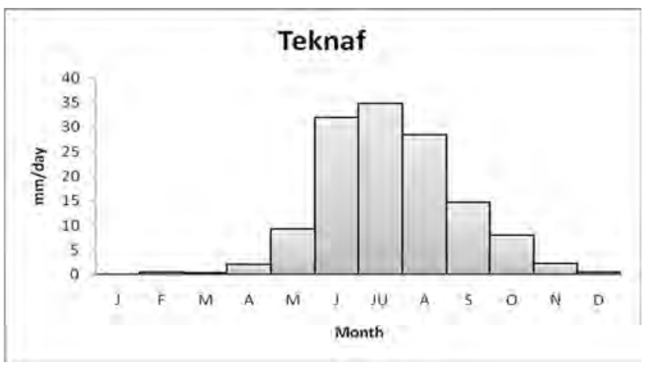

Barisal
mm/day
Month

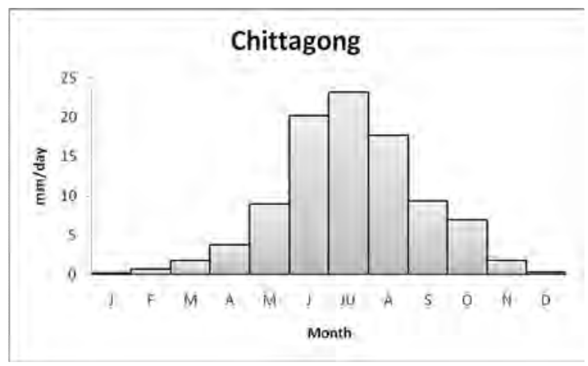

Bhola
mm/day
J F M A M J JU A S O N D
Month

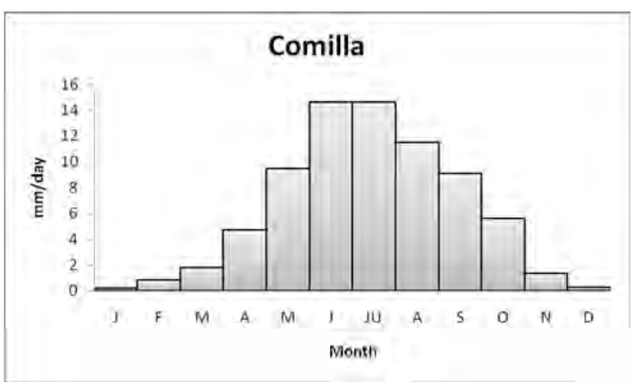

Khepupara
mm/day
J F M A M J JU A S O N D
Month

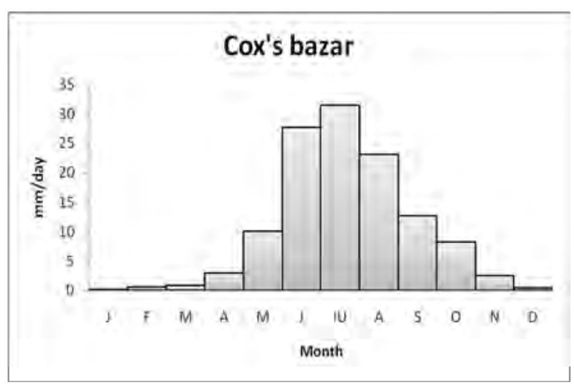

Patuakhali
mm/day
J F M A M J JU A S O N D
Month

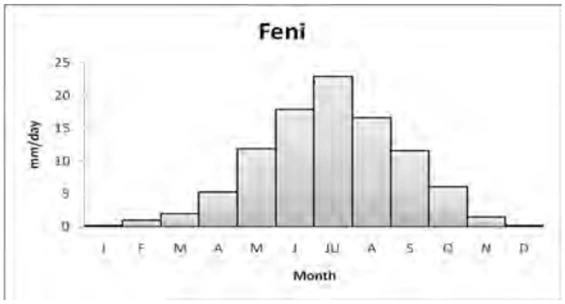

Chandpur
mm/day
J F M A M J JU A S O N D
Month

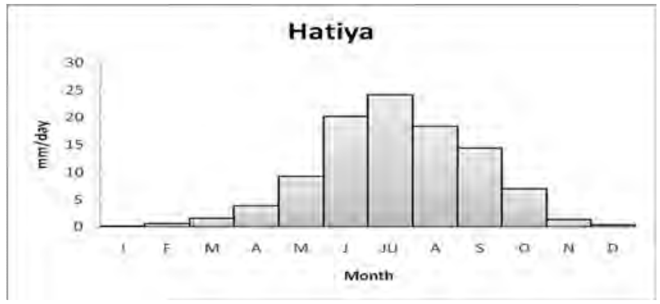

Teknaf
mm/day
J F M A M J JU A S O N D
Month

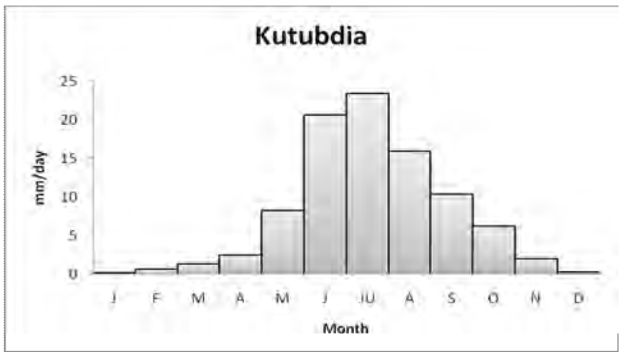

Chittagong
mm/day
J F M A M J JU A S O N D
Month

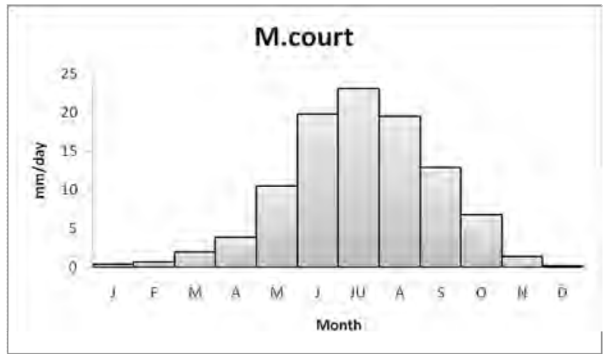

Comilla
mm/day
J F M A M J JU A S O N D
Month

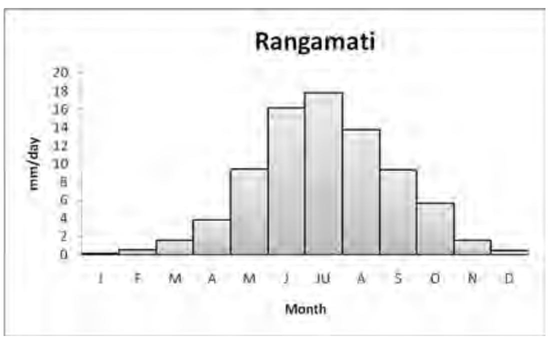

Cox's bazar
mm/day
J F M A M J JU A S O N D
Month

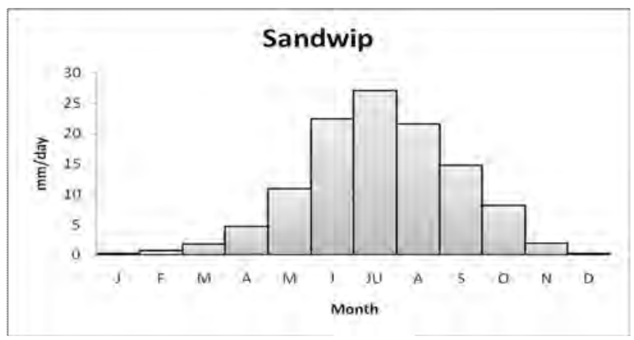

Feni
mm/day
0
5
10
15
20
25
J F M A M J JU A S O N D
Month

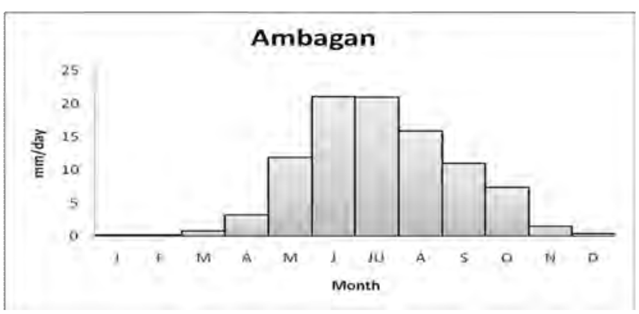

Hatiya
mm/day
0
5
10
15
20
25
30
J F M A M J JU A S O N D
Month

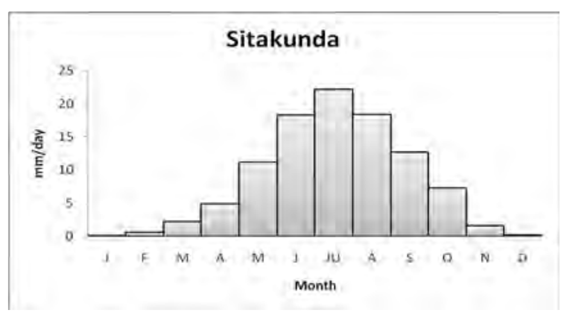

Kutubdia
mm/day
0
5
10
15
20
25
J F M A M J JU A S O N D
Month

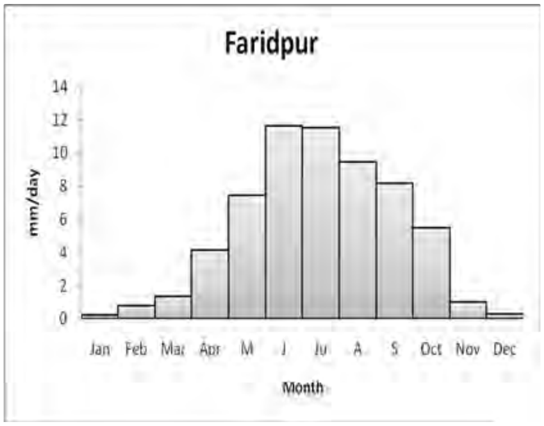

M.court
mm/day
0
5
10
15
20
25
J F M A M J JU A S O N D
Month

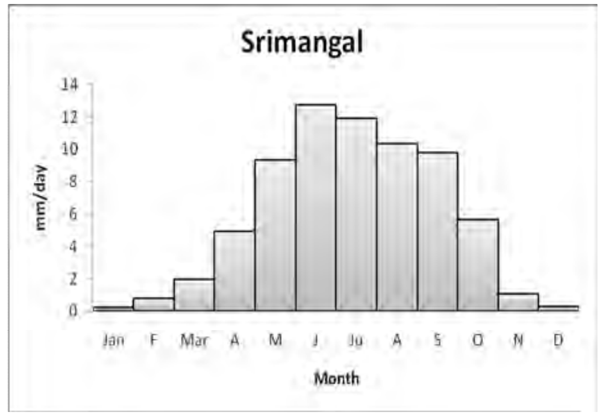

Rangamati
mm/day
0
2
4
6
8
10
12
14
16
18
20
J F M A M J JU A S O N D
Month

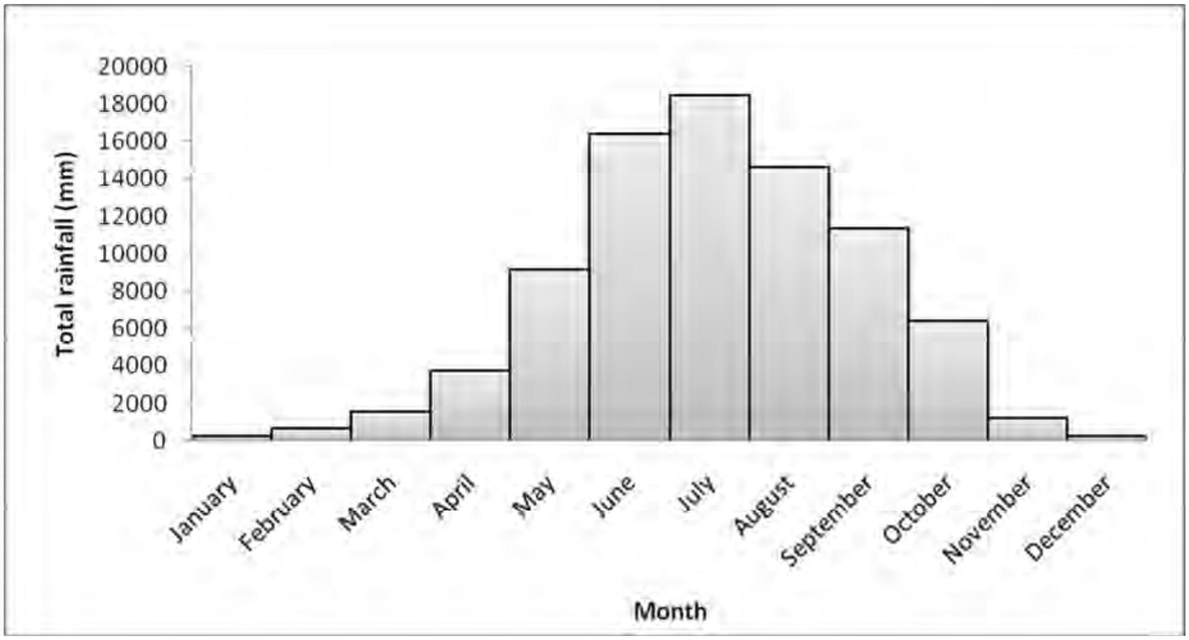

Sandwip
mm/day
0
5
10
15
20
25
30
J F M A M J JU A S O N D
Month

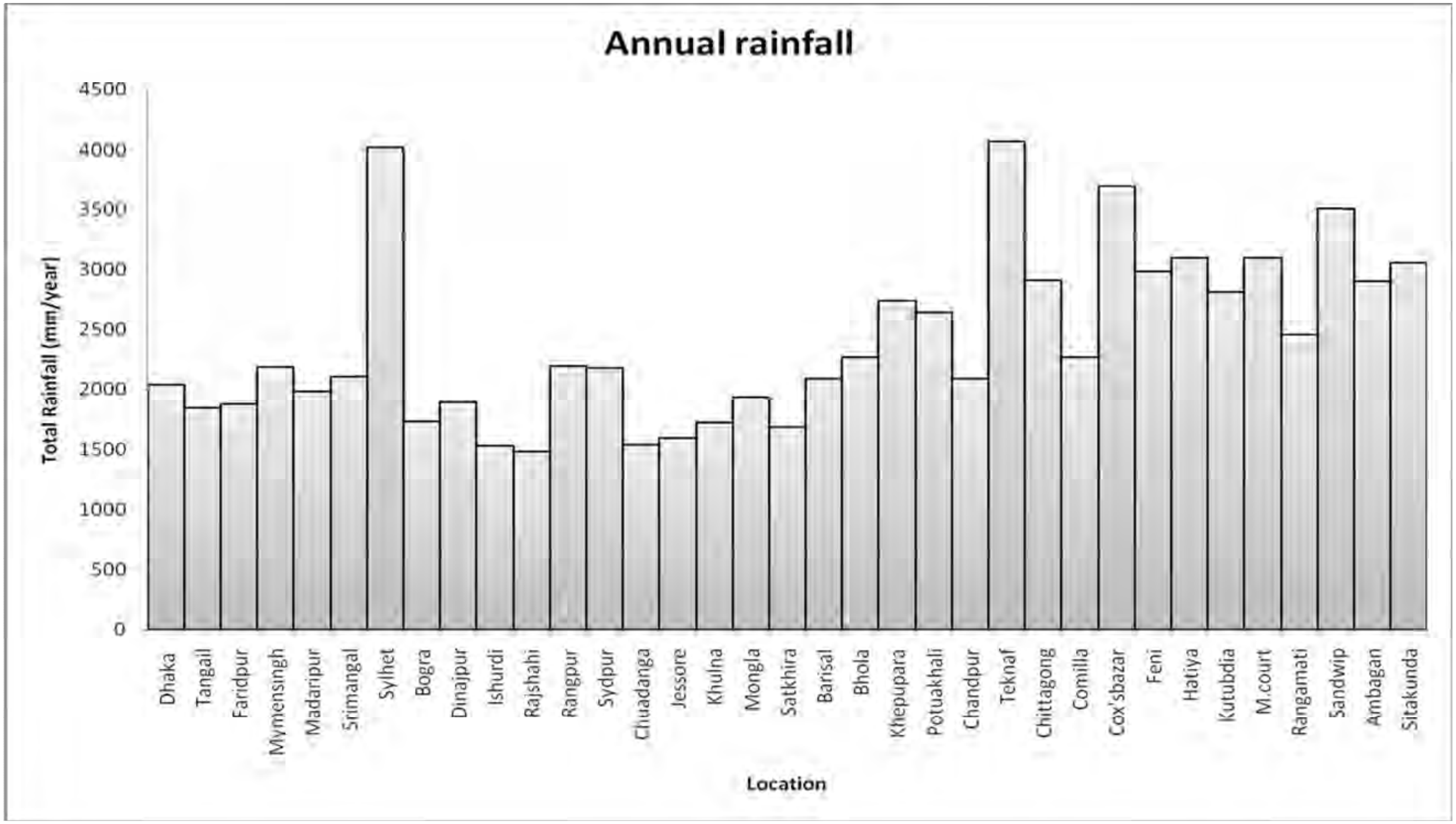

Ambagan
mm/day
0
5
10
15
20
25
J F M A M J JU A S O N D
Month

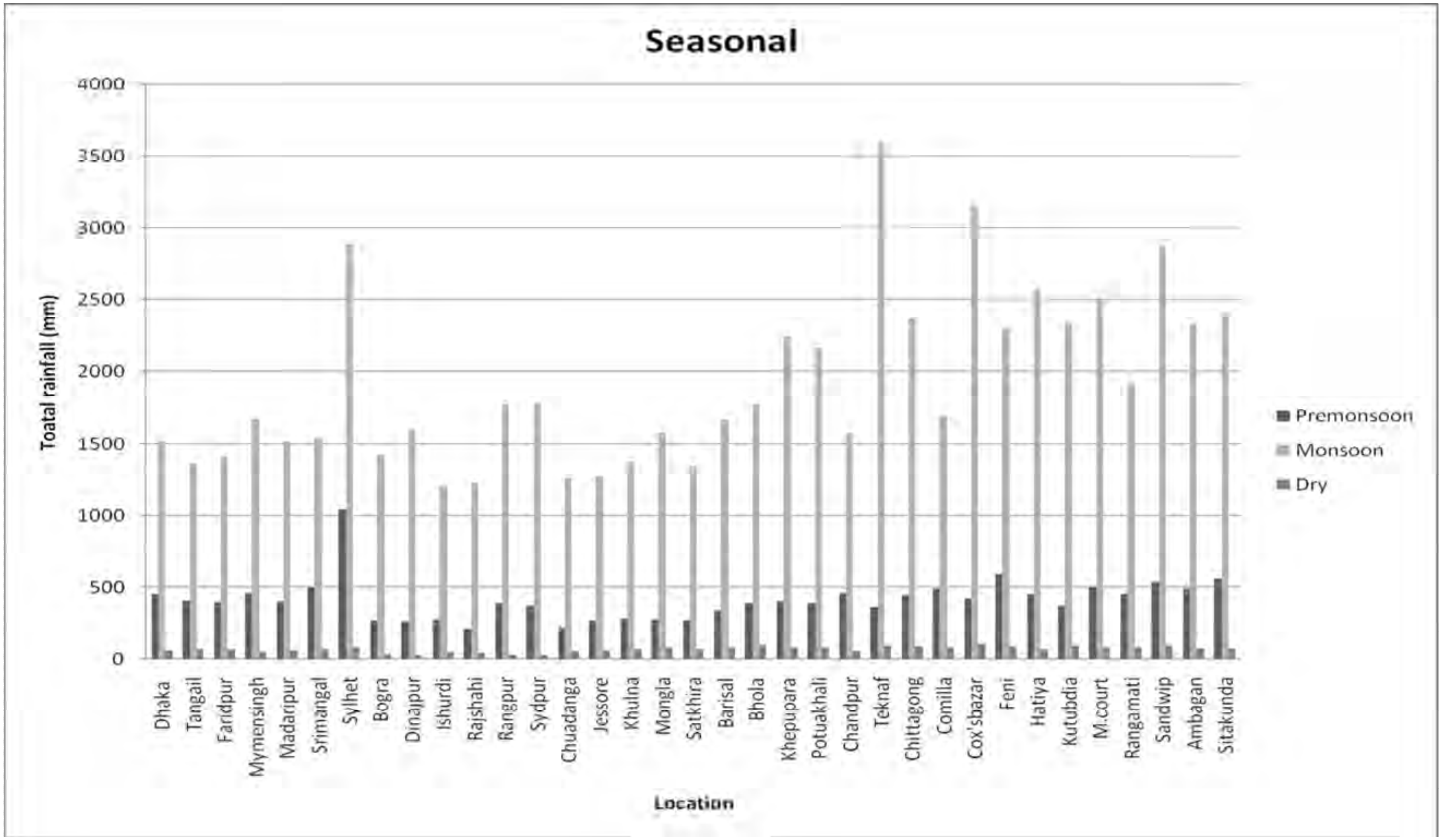

Sitakunda
mm/day
0
5
10
15
20
25
J F M A M J JU A S O N D
Month


Faridpur
14
12
10
8
6
4
2
0
mm/day
Jan Feb Mar Apr M J Ju A S Oct Nov Dec
Month


Srimangal
14
12
10
8
6
4
2
0
mm/day
Jan F Mar A M J Ju A S O N D
Month


20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Total rainfall (mm)
January
February
March
April
May
June
July
August
September
October
November
December
Month


Annual rainfall
Total Rainfall (mm/year)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Dhaka
Tangail
Faridpur
Mymensingh
Madaripur
Srimangal
Sylhet
Bogra
Dinajpur
Ishurdi
Rajshahi
Rangpur
Sydpur
Chuadanga
Jessore
Khulna
Mongla
Satkhira
Barisal
Bhola
Khepupara
Potuakhali
Chandpur
Teknaf
Chittagong
Comilla
Cox'sbazar
Feni
Hatiya
Kutubdia
M.court
Rangamati
Sandwip
Ambagan
Sitakunda
Location



Seasonal
4000
3500
3000
2500
2000
1500
1000
500
0
Toatal rainfall (mm)
Dhaka
Tangail
Faridpur
Mymensingh
Madaripur
Srimangal
Sylhet
Bogra
Dinajpur
Ishurdi
Rajshahi
Rangpur
Sydpur
Chuadanga
Jessore
Khulna
Mongla
Satkhira
Barisal
Bhola
Khepupara
Potuakhali
Chandpur
Teknaf
Chittagong
Comilla
Cox'sbazar
Feni
Hatiya
Kutubdia
M.court
Rangamati
Sandwip
Ambagan
Sitakunda
Location
Premonsoon
Monsoon
Dry