Trend and Variability Analysis of Sunshine Duration in Divisional Headquarters of Bangladesh

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Abstract
In this study, Sunshine duration data of eight divisional headquarters of Bangladesh Meteorological Stations (Dhaka, Rangpur, Rajshahi, Mymensingh, Sylhet, Barishal, Khulna and Chattagram) were analyzed to evaluate the long-term changes and trends. The data used are the BMD data spanning from 1980 to 2010. The annual sunshine duration has decreased by the month of (June –September) from 1980 to 2010. Seasonal changes in sunshine duration were also analyzed where the maximum decline was found in rainy-monsoon season (June – September), the winter season (December – February), then the post-monsoon season (October – November) and the minimum in the pre-monsoon season (March – May). Analysis of observed data before and after 2000 represents the sunshine durations have decreasing trends in all divisional headquarters of Bangladesh except Chattagram station during the month of (January – December). General Circulation Model (GCM) defined that the maximum sunshine hour was decline north-east and south-west in all divisional headquarters of Bangladesh during the month of (June – September) and the minimum sunshine hour was decline in eastern part of the country during the month of (March – May).

Key words: Bangladesh, Meteorology, Sunshine, Trend and variability

Introduction

Sunshine hour is one of the vital climatic phenomena for agriculture. Adequate sunshine and proper sunshine hour are essential for required plant growth and development. Poor crop growth may occur due to lack of bright sunshine. Intense light protects the plants against injury. Daylight duration is important for raising crops in any latitude and it influences the flowering of plants. Sunlight plays a crucial role on stomata opening and photosynthetic capacity too. Inadequate light may cause different diseases, structural changes and alteration of color. Light saturation is a condition of a leaf or plant receiving that amount of light or more to produce the maximum photosynthetic under prevailing conditions of CO_2 and light supply (Lenka, 1998). Solar radiation received by the earth is the primary source of energy that drives the climate system, natural and anthropogenic change in insolation therefore has important implications for climate change studies as well as for agriculture, water resources, and solar energy applications (Power, 2003). Solar radiation plays a major role in determining biomass production and grain yield. As sunshine duration is an important factor in photosynthesis (carbon assimilation) and thus production of rice, variations in sunshine hours may influence rice production (Samui, 1999). Long-term measurements of pan evaporation rates indicate that evaporation rates have fallen. Roderick and Farquhar (2002) provide evidence for this phenomenon. This is an apparent paradox: as the average global temperature increases the pan evaporation rate actually decreases. Yet, it was found that the rise of temperature is not the main factor in the evaporation rate. The amount of sunlight reaching the surface of our planet was found to be the main contributory factor for the evaporation process. Weather prediction is a complex process and a challenging task for researchers. The prediction of atmospheric parameters is essential for various applications. Some of them include climate monitoring, drought detection, severe weather prediction, agriculture and production. A US research team has found evidence suggesting that India's shrinking rice harvests, which have been declining since the 1980, have been caused by the polluted clouds that are shrouding a large portion of South Asia and reducing sunlight and rainfall. The researchers used climate models and historical data concerning Indian rice harvests and found if there had been no atmospheric brown clouds between 1985 and 1998, the annual rice harvest yield would have been 11% higher than it was (Kage, 2006). Findings of the study, sunshine duration rates have gruesome declined at the last decades in all divisional headquarters of Bangladesh except Chattagram station during the month of (January to December).

Methodology

Study area

Bangladesh is a small south Asian country with an area of 147,570 km^2 and located between latitudes 20.59°–26.63°N and longitudes 88.01°–92.67°E. All divisional headquarters of Bangladesh with their meteorological stations are (Rangpur, Rajshahi, Mymensingh, Sylhet, Dhaka, Khulna, Barishal and Chattagram).

Data collection and analysis

There are about 35 meteorological stations under Bangladesh Meteorological Department (BMD) in Bangladesh. To reduce analysis volume, eight stations located at different administrative divisions of Bangladesh were selected in this study. The located stations were Rajshahi and Rangpur (North-West zone), Dhaka (North-Central zone), Sylhet and Mymensingh (North-East zone), Khulna (South-West zone), Barisal (South-Central) and Chattagram (Eastern) hilly regions.

The reasons behind selecting these stations are availability of the long term data, minimum missing observations and covering almost all topological region of Bangladesh. The missing data are filled in by the median of the corresponding years.

The duration of the study period was chosen as 1980 to 2010 for Dhaka (1961-2010), Sylhet (1961-2010), Barishal (1967-2010), Chattagram (1977-2010), Rajshahi (1979-2010), Mymensingh (1979-2010), Khulna (1984-2010), Rangpur (1985-2010).

The analysis is based on average value**.** The data analyzed are four distinct seasons: (1) the dry winter season (December to February), (2) the pre-monsoon hot summer season (March to May), (3) the rainy monsoon season (June to September), and (4) the post-monsoon autumn season which lasts (October to November) (Shahid, 2010). Eight divisional headquarters divided into two parts: Northern Region (Rangpur, Rajshahi, Mymensingh, Sylhet) and Southern Region (Dhaka, Chattagram, Khulna, Barishal) the data were analyzed based on mean values.

Composite mapping and General Circulation Model (GCM)

The composite mapping for GCM has been done through the National Centre for Environmental Prediction (NCEP) – National Centre for Atmosphere Research (NCAR) reanalysis project (Kalnay *et al*., 1996), which ensures a good resolution of atmospheric data with a grid of 2.5° resolution**.** Global climate model also known as General Circulation Model (GCM) is the most complex of climate models, since they attempt to represent the main components of the climate system in three dimensions. GCMs are the tools used to perform climate change experiments from which climate change scenarios (possible representations of how the climate will evolve) can be constructed. The design and structure of an individual GCM determines the climate change experiments that can be performed.

Results and Discussion

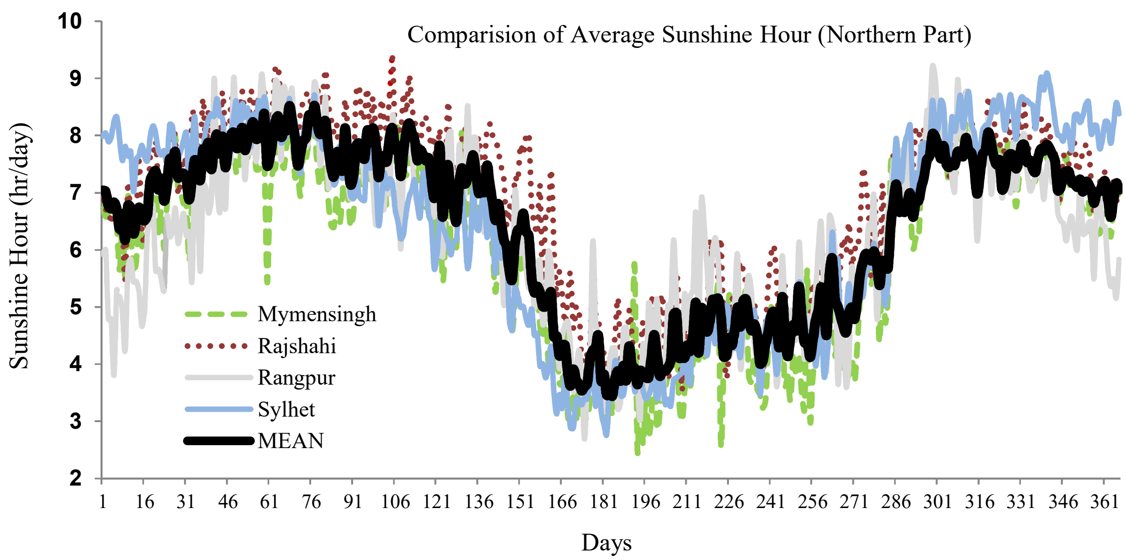

Fig. 1. Trend of sunshine hour in four divisional headquarters of Northern Bangladesh

The within-days trends for annual of eight divisional headquarters of Northern (Mymensingh, Rajshahi, Rangpur and Sylhet) Bangladesh are analyzed and the results are presented in the Figure 1. From the figure, variabilities of sunshine hour are more fluctuated during the day of (1th – 365th DOY) and it's compared with mean values. Only Rajshahi station has shown the sunshine duration is upper than mean values in the overall days.

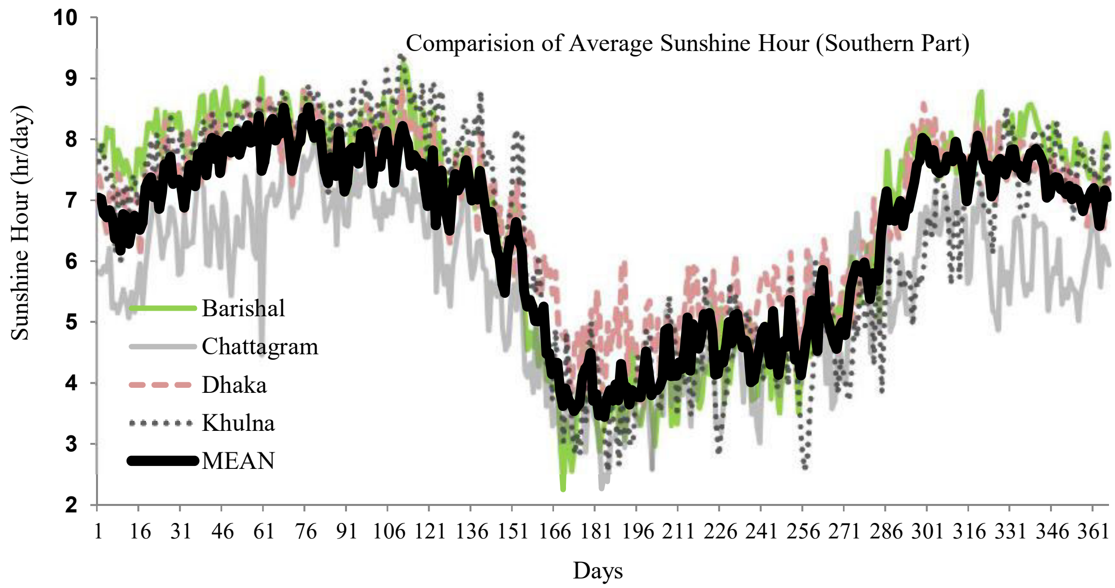

Fig. 2. Trend of sunshine hour in four divisional headquarters of Southern Bangladesh

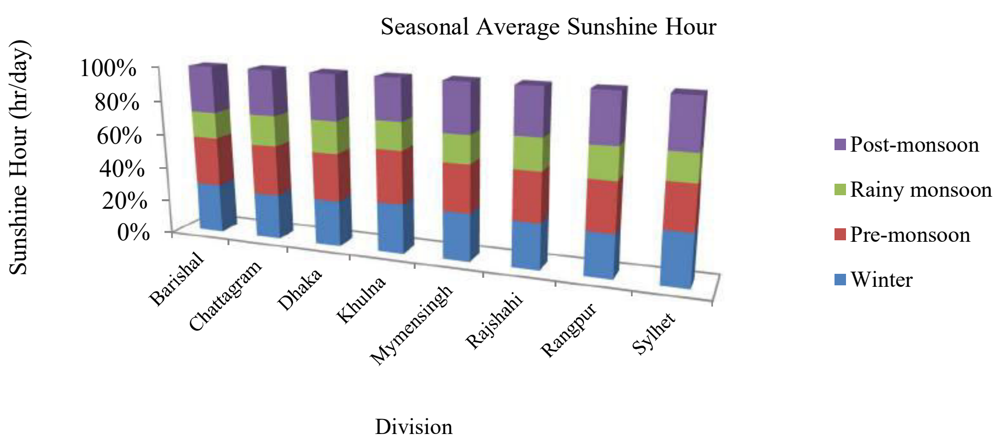

Fig. 3. Seasonal average sunshine hour in 8 divisional headquarters of Bangladesh

To see the changes in sunshine duration in different seasons within a year, average sunshine duration in Post-monsoon (October – November), Rainy-monsoon (June – September), Pre-monsoon (March – May) and winter (December – February) were calculated. The result of the analysis is reported in Figure 3. It is found that the highest decline rates during rainy-monsoon, then the winter, then the post-monsoon and lowest sunshine duration is found pre-monsoon seasons in eight divisional headquarters of Bangladesh. During the rainy-monsoon, cloud concentrations are higher, while during the other seasons. This could be the possible reason for a higher rate of decline in sunshine hour in the pre-monsoon season compared to that of the other seasons.

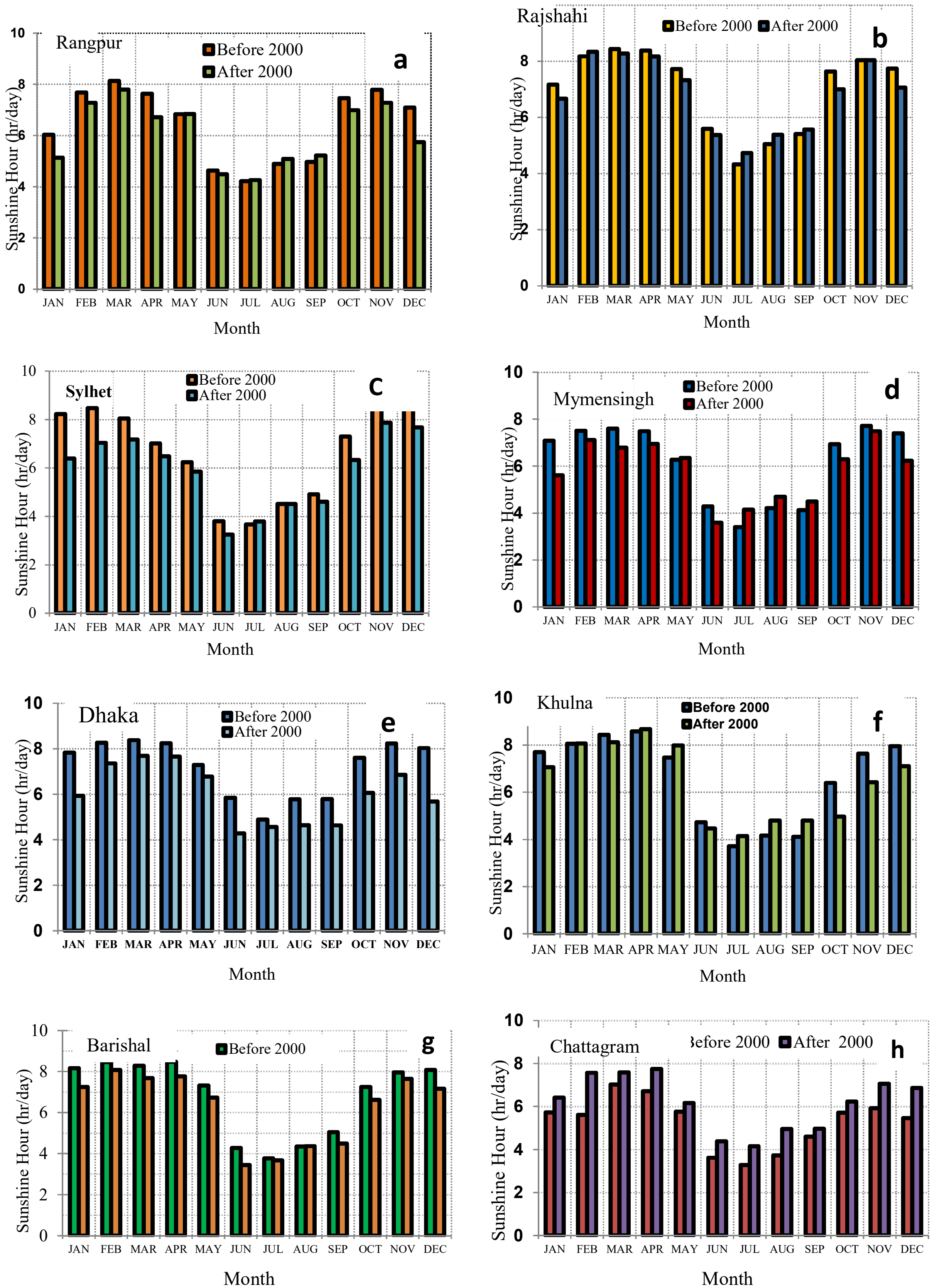

Fig. 4. Monthly average sunshine hours before and after 2000 (a) Rangpur (b) Rajshahi (c) Sylhet (d) Mymensingh (e) Dhaka (f) Khulna (g) Barishal (h) Chattagram divisional headquarters of Bangladesh

To see the monthly average sunshine hour before and after 2000 in eight divisional headquarters (Rangpur, Rajshahi, Sylhet, Mymensingh, Dhaka, Khulna, Barishal and Chattagram) of Bangladesh. The result is indicated in Figure 4. From the figure, trend of sunshine hour is decreasing after 2000 in all divisional headquarters of Bangladesh but only Chattagram station has shown the increasing rates after 2000 during the month of (January - December). Sunshine hour is dramatically and drastically declined during the month of (June – September) in all divisional stations. Enormous cloudiness this could be the potential cause the decline rates of sunshine hour.

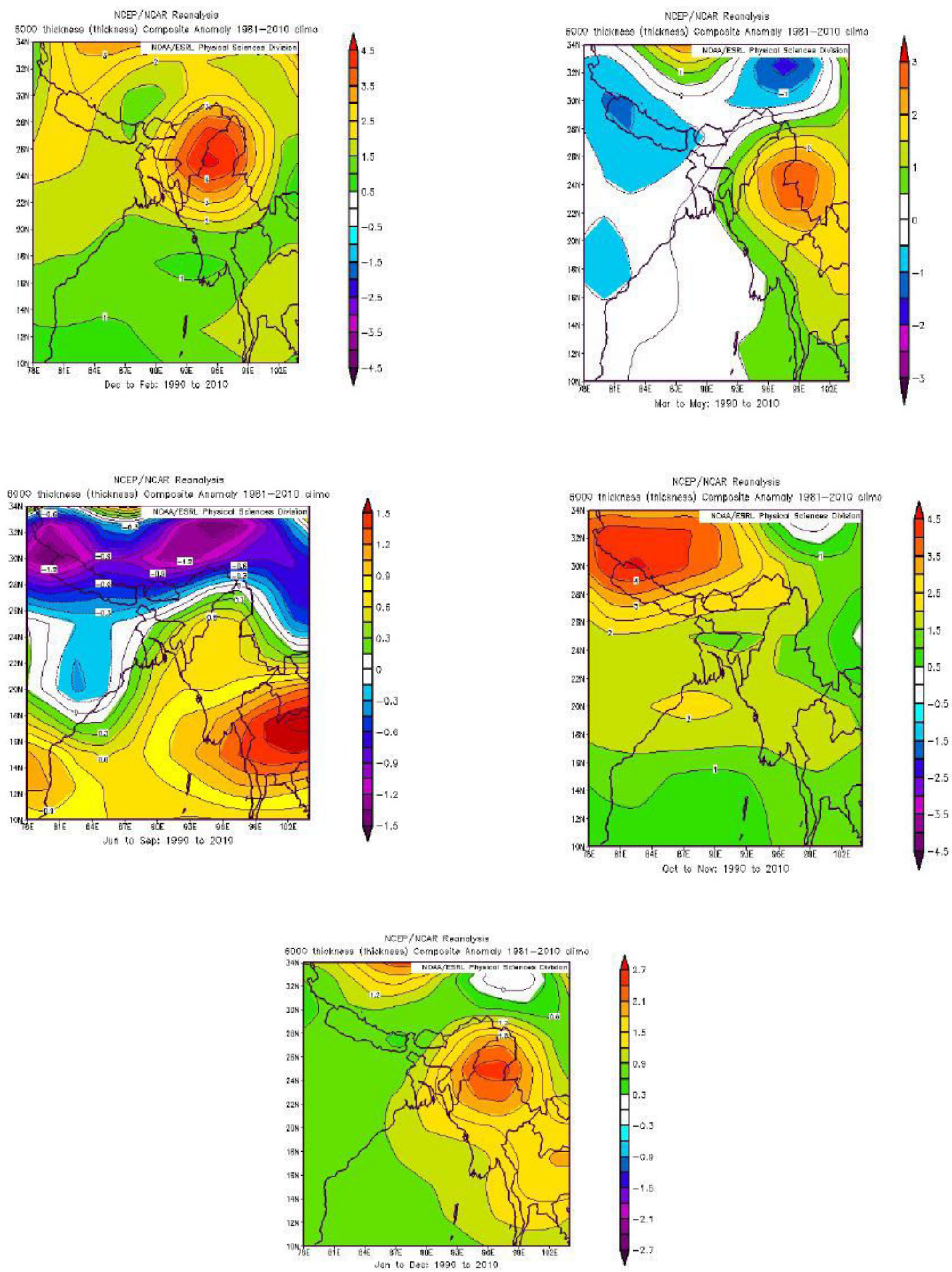

Fig. 5. The pattern of composite anomaly of sunshine hour (a) December – February (b) March- May (c) June – September (d) October – November (e) January – December

Conclusions

The foregoing analyses indicate that the annual and seasonal average follow significant negative trend in all the eight stations with a few exceptions. Sunshine duration data at eight divisional headquarters of meteorological stations for a period of 30 years (1980 – 2010) were analyzed. The decline rate is very prominent in the rainy-monsoon season (June – September). Monthly mean sunshine hour before and after 2000 represent the sunshine duration rates are more declined after 2000 in all divisional headquarters of Bangladesh except Chattagram station during the month of (January – December).

So, it can be included that the availability of sunshine-hour is decreasing which will definitely have some awkward impacts on plant growth, yield and quality of its produce.

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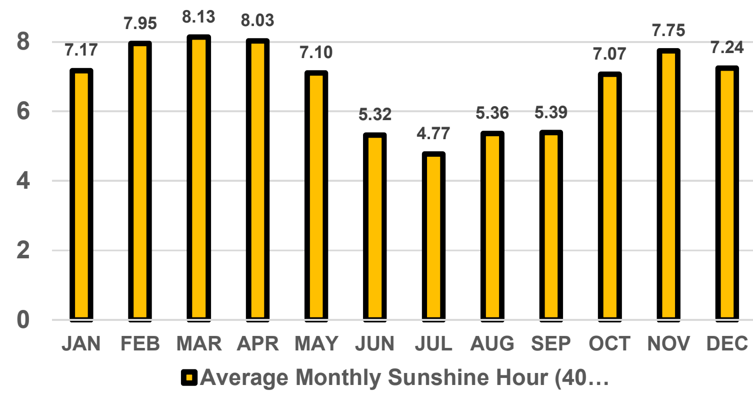
APPENDICES

Appendix I: Available periods of sunshine duration at selected BMD stations

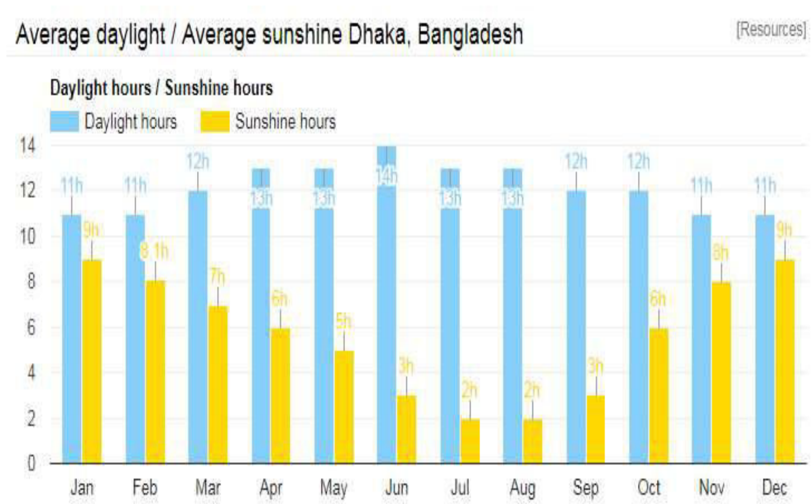
Station	Available Period of Records	LAT. (°N)	LONG. (°E)
Dhaka	1961 – 2010	23.78	90.39
Sylhet	1961 – 2010	24.88	91.93
Barishal	1967 – 2010	22.70	90.36
Chattagram	1977 – 2010	22.34	91.79
Rajshahi	1979 – 2010	24.35	88.56
Mymensingh	1979 – 2010	24.75	90.41
Khulna	1984 – 2010	22.80	89.58
Rangpur	1985 – 2010	25.72	89.26

Appendix II: Average Monthly Sunshine Hour (40 yr) Dhaka Divisional Headquarters of Bangladesh



Source: (https://bmd.gov.bd)

Appendix III: Average Sunshine Dhaka, Bangladesh



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