Measurement and Estimation of sunshine duration for Bangladesh

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Abstract

Sunshine duration recorders are widely used to estimate global radiation from sunshine duration data using Angstrom type correlations. The number of pyranometer stations that measure global radiation is inadequate in Bangladesh. 31 stations of Bangladesh Meteorological department records both sunshine duration and cloud cover data. A study of the data shows that 6 of the stations do not have satisfactory data for sunshine duration, while cloud cover data for all stations appear to be reasonably good. An attempt has therefore been taken to correlate cloud cover with sunshine duration to estimate sunshine hours for the 6 stations. In this paper two methods have been used to estimate sunshine duration from cloud cover. For method 1, correlation has been developed between fractions of possible sunshine duration and cloud cover amounts. For method 2, correlation has been developed between possible sunshine duration and numbers of clear, mixed and overcast days per month. The r.m.s. errors have been found 0.4-0.5 hour and 0.3-0.5 hour for the methods respectively. For both the cases January was treated separately because in this month there is a small influence of fog on cloud cover and correlations have been obtained for 11 months of the year. For January a fog factor of 0.85-1.00 was introduced for stations with a number of foggy days in the month.

Introduction:

For quality assessment of data (1992-2001), several graphs have been studied of cloud cover and sunshine duration. The variations of sunshine duration and cloud cover with months are given below:

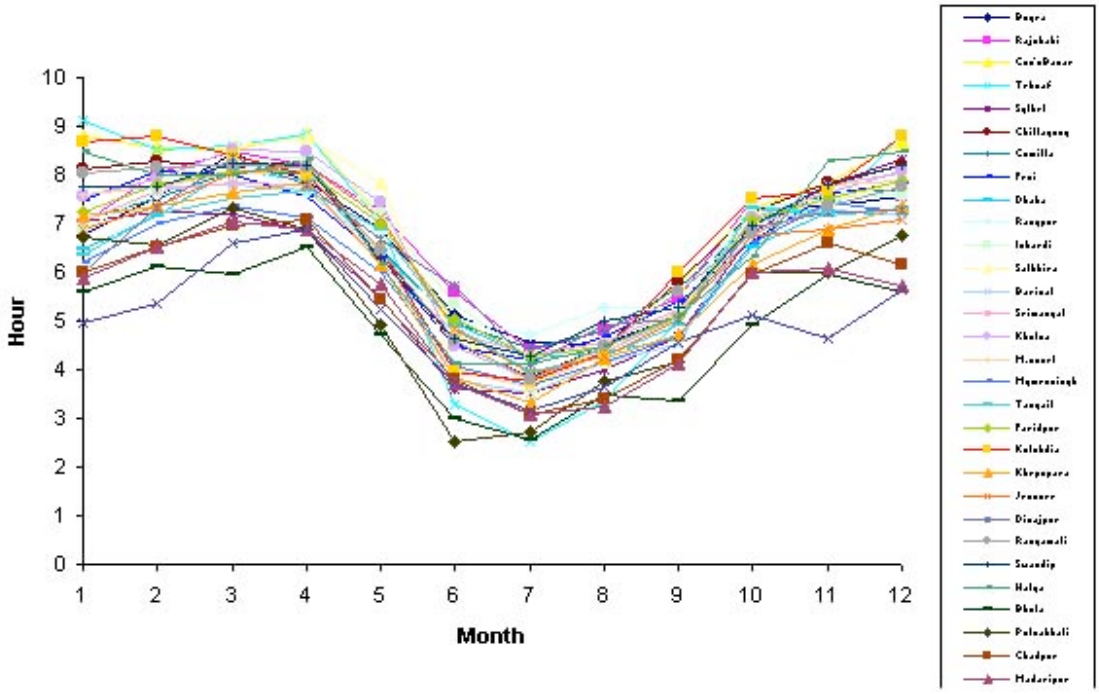

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Figure 1: Variation of sunshine duration with months for all BMD stations

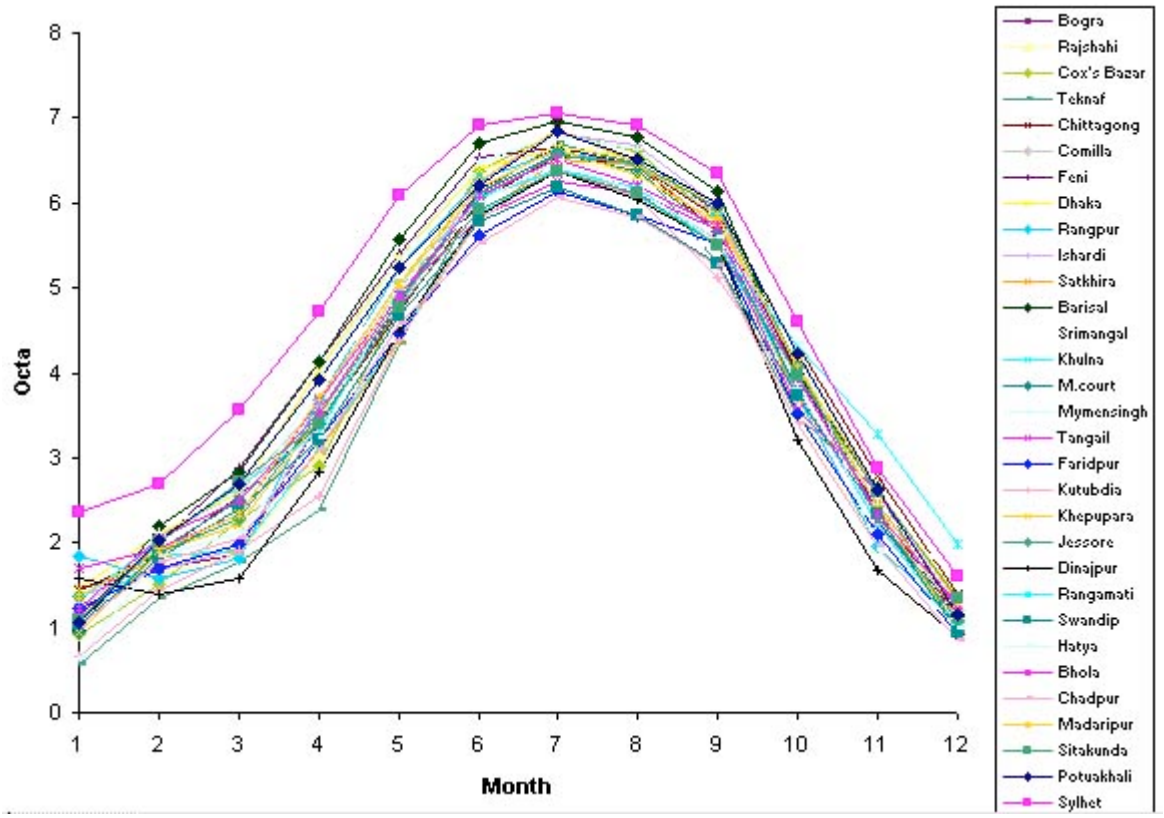

Figure 2: Variation of cloud cover with months for all BMD stations

The variations of sunshine duration and cloud cover with years are given below:

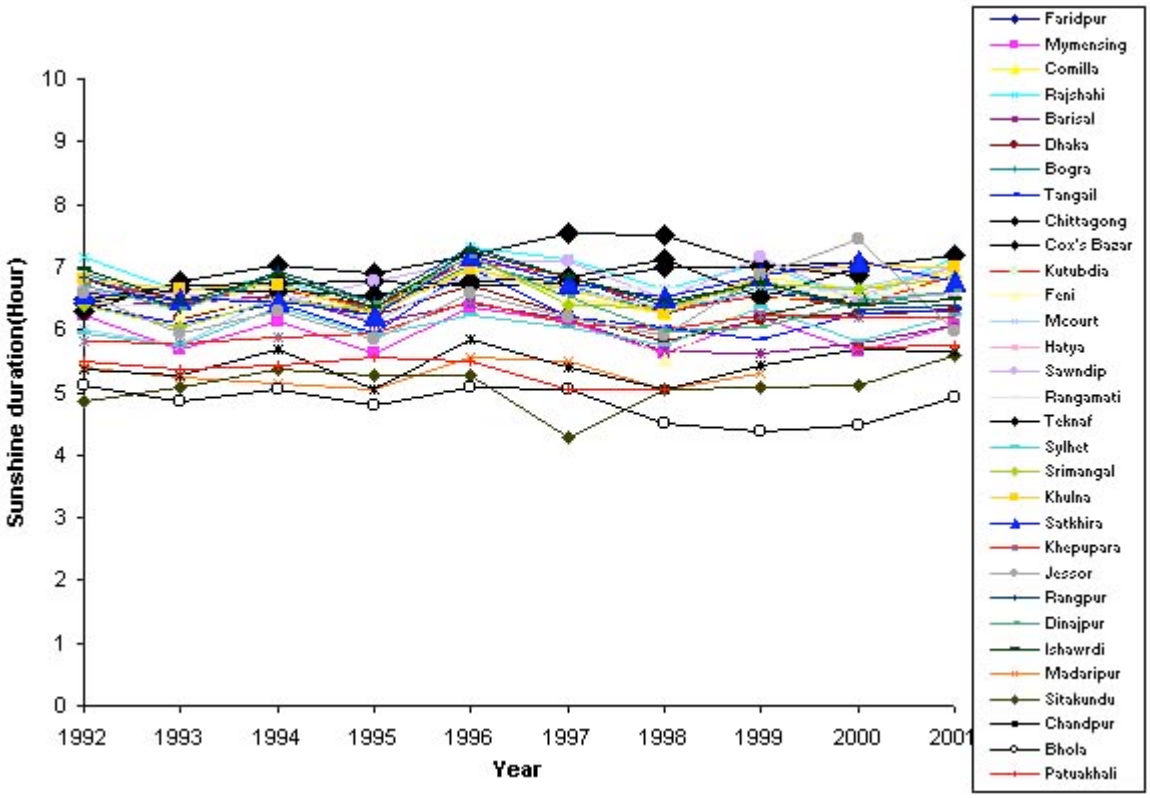

Figure 3: Variation of sunshine duration with years for all BMD stations

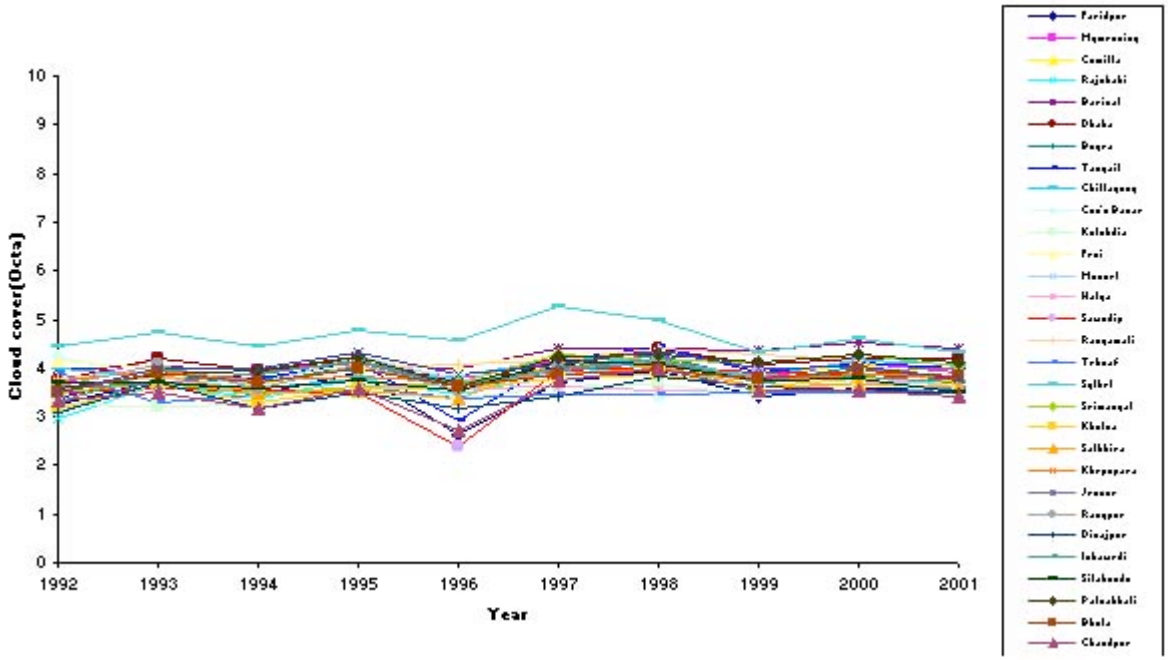

Figure 4:Variation of cloud cover with years for all BMD stations

Cloud cover is a specifier of sunshine duration. Hence the variation of sunshine duration and cloud cover amount should be correlated.
With years variations of annual sunshine duration and cloud cover both in a graph are shown below for two stations having different status:

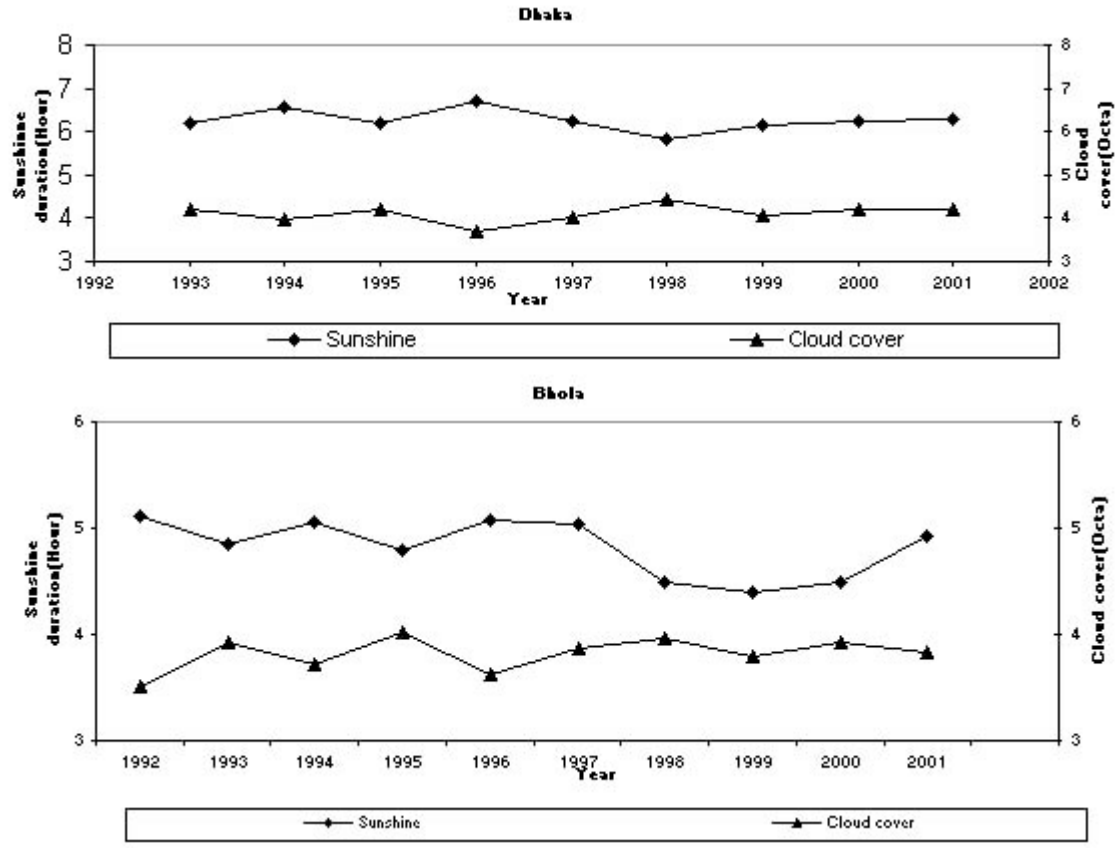

Figure 5: Variation of sunshine duration and cloud cover both in a graph

Some stations have uncorrelated variation of sunshine duration with cloud cover, unsatisfactory alignments or shading. Such type of stations is 6 in number.

In view of the fact that the number of stations with satisfactory long term records of sunshine duration was small in Bangladesh attempts had been made to estimate sunshine duration from cloud cover data using suitable correlations in year 1990 by M Hossain [1]. As Met. Dept. has been using local cards since 1990 an attempt has been taken to estimate sunshine duration from cloud cover.

In this paper two methods were used to estimate the sunshine duration.
First method developed a relation with cloud cover. This method separated the stations on positions of upper and lower latitude of 23.5^0 for fine estimation.

Second method developed a relation with state of the sky defining on the ground of the daily mean cloudiness according to the table1 given below:

Table 1:Classifcation of the days on ground of cloudiness degree eights

Cloud cover amount (in Octa)	
0-2	Clear day
2-4	Mixed day
4-8	Overcast day

Measurement methods:

Method 1: From cloud cover amount:

In this method for months of year except January the correlation used was

$$\frac{n}{N'} = a + bx + cx^2 + dx^3,$$

where x is the monthly averaged daily cloud cover amount (in octa), n is the number of bright sunshine hours and N' is the period when the Campbell-Stokes sunshine recorder remains sensitive [2]. $N' = \frac{\arccos\left(\frac{\cos 85 - \sin\phi \sin\delta}{\cos\phi \cos\delta}\right)}{7.5}$, ϕ is the latitude of the station and δ is the declination.

The parameters of the correlation were obtained using data of 9 stations above 23.5^0 latitude and 10 stations below 23.5^0 latitude.

The graphs are given on the next page:

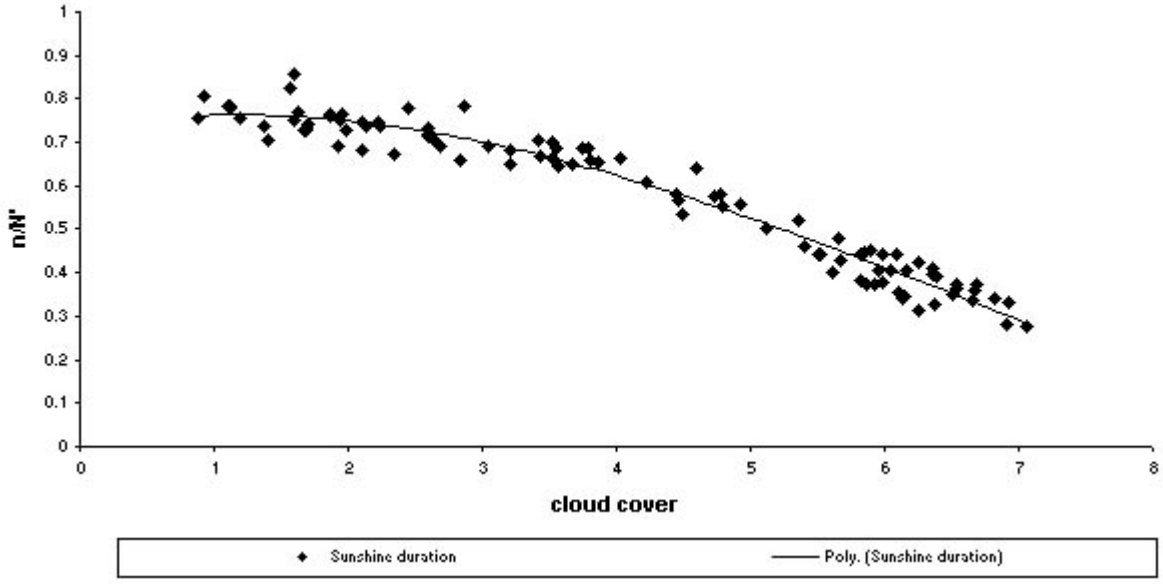

Figure 6(a): Fits for n/N' versus cloud cover for stations positioning upper of Lat. 23.5^0

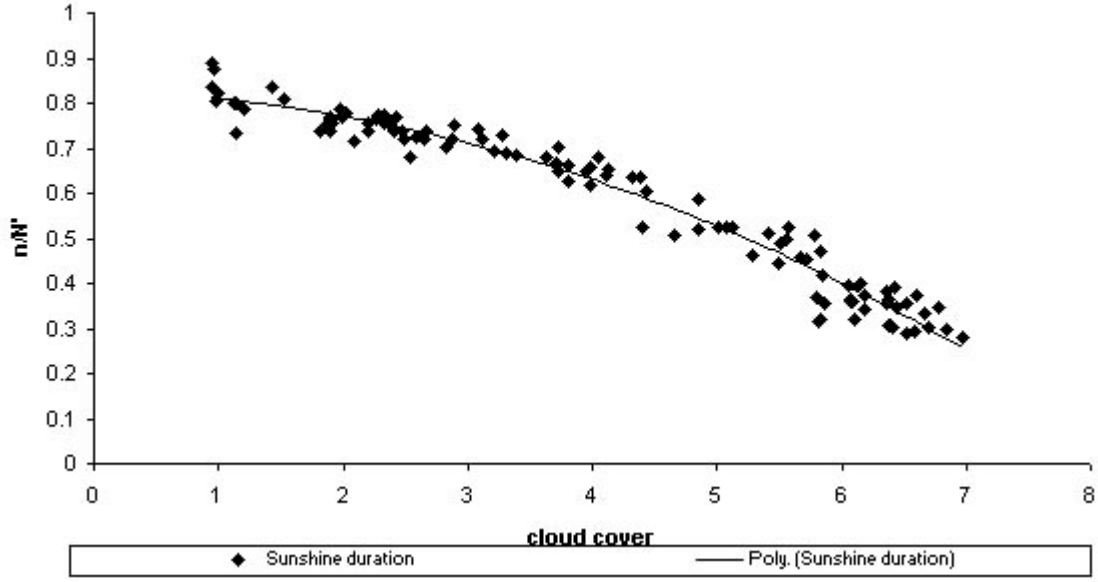

Figure 6(b): Fits for n/N' versus cloud cover for stations positioning below of Lat. 23.5^0

The parameters are given in the following table.
Table 2: Regression parameters:

	a	b	c	d
Statios above Latitude 23.5^0	0.732	0.055	-0.025	0.001
Statios below Latitude 23.5^0	0.832	-0.012	-0.001	-0.0002

The r.m.s. errors have been found to be 0.5 hour and 0.4 hour for stations above and below Lat. 23.5^0.

Method 2: from the state of the sky:

In this method for 11 months a relation between relative sunshine duration and state of the sky has been employed following Barbaro [3]. The state of the sky is defined by the number of clear days (n_1), mixed days (n_2) and overcast days (n_3) in a month and the correlation is,

$$\frac{n}{N'} = \frac{an_1 + bn_2 + cn_3}{n_{123}}$$

where $n_{123} = n_1 + n_2 + n_3$ is the total number of days in the month under consideration and a, b and c are climatological parameters.

To apply the method the stations were sorted into medium rainfall stations and high rainfall stations. The parameters were found using data of 8 medium rainfall stations and 4 high rainfall stations.
The parameters are given in Table 3.

Table 3: The climatogical parameters:

Station type	Value of a,b&c	Jan-Apr	May	Jun	Jul	Aug	Sep	Oct-Dec
Medium rainfall	a=0.85 b=0.7							
	c=	0.5	0.5	0.35	0.32	0.37	0.4	0.5
High rainfall	a=0.9 b=0.7							
	c=	0.5	0.42	0.32	0.3	0.35	0.45	0.5

The r.m.s. errors have been found 0.3 hour and 0.5 hour for medium and high rainfall stations respectively.

For January a fog factor of 0.85-1.00 was introduced for stations with a number of foggy days in the month. This value has been found that it differs with station positions and has been estimated by observing the number of foggy day for few years, the ratio of measured and estimated values.

Results:
Sunshine duration of each station has been estimated using both methods. The second method has been found to give closer of the measured value for each month and annual. For 6 stations sunshine duration is estimated using this second method. Some stations of number 5 have found to have comparatively a large difference between measured and estimated by method 2. For these stations average of two has been taken.

The values of annual sunshine duration of all Met. stations are given on the next page (measured values of estimated stations are given in first braces):

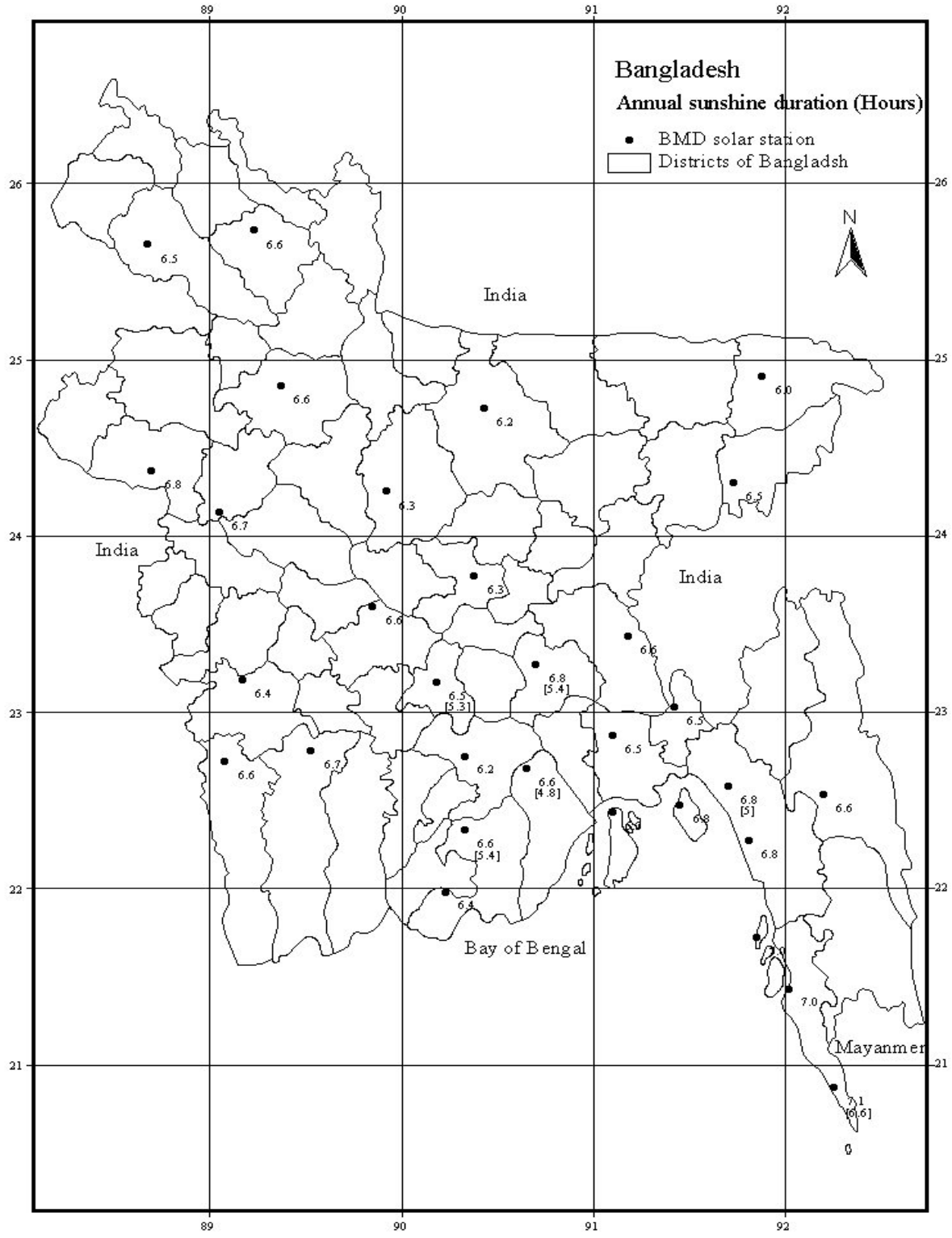

Figure 7: Sunshine duration of all stations of BMD

Discussion:

According to the methods sunshine duration for all stations of BMD has been presented. To draw maps require more data of different positions. Rainfall data of period 1902-1972 of more than 300 stations exists, which may be used in roughly predicting sunshine duration of different positions and completing maps.

Reference:

[1] Hussain, M. and Siddique, D., 1990. On correlating the relative sunshine duration with the state of the sky. Solar and Wind Technology, 7, 5, 555-557.

[2] S. Rangarajan, M.S. Swaminathan and A. Mani, 1984. Computation of solar radiation from observations of cloud cover. Solar Energy, 32, 553-556.

[3] Barbaro, S., Cannata, G., Coppolino, S., Leone, C. and Sinagra, E., 1981. Correlation between relative sunshine duration and state of the sky. Solar Energy, 26, 537-550.