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Climatic classification of Bangladesh

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सार — 16 केन्द्रों के 27 वर्षों के जलवायुविक आंकड़ों के उपयोग से बंगलादेश की जलवायु को आइवनोव (1941, 1956, 1958), सिलिनियोव (1966), गॉरसिनकि और शीवर (1976) की पद्धति के द्वारा वर्गीकृत करने का प्रयास किया गया है। आइवनोव की पद्धति के उपयोग से यह सिद्ध हुआ है कि बंगलादेश में तीन जलवायुविक क्षेत्र हैं : (*i*) इनमें से पहला "साधारण आर्द्र जलवायु" वाला क्षेत्र है जिसमें बंगलादेश के पश्चिमी सीमांत जिले आते हैं, (*ii*) दूसरा, "पर्याप्त आर्द्र जलवायु" वाला क्षेत्र है जिसमें बंगलादेश के मुख्यत: 90°पू. देशांतर के पश्चिमी क्षेत्र आते हैं और (*iii*) तीसरा "उत्तम आर्द्र जलवायु" वाला क्षेत्र है जिसमें बंगलादेश के मुख्यत: 90° पू. देशांतर के पूर्वी क्षेत्र आते हैं। सिलिनियोव पद्धति से भी लगभग इसी प्रकार के जलवायुविक क्षेत्रों का पता चला है। गॉरसिनकि पद्धति से बंगलादेश में निम्नलिखित तीन जलवायुविक क्षेत्रों का पता चला : (*i*) अर्ध-सागरीय जलवायु — दक्षिण-पूर्वी और उत्तर-पूर्वी पर्वतीय क्षेत्र ; (*ii*) मैदानी भूमि जलवायु — देश का मध्यवर्ती भाग और (*iii*) अर्ध-महाद्वीपीय जलवायु — पश्चिम सीमांत जिले। शीवर पद्धति से पता चला कि बंगलादेश में "तीक्ष्ण महाद्वीपीय" प्रकार की जलवायु है।

ABSTRACT. Using climatological data for 27 years of 16 stations, an attempt has been made to classify the climate of Bangladesh by the method of Ivanov (1941, 1956 & 1958), Selianinov (1966), Gorsinkii and Shever (1976). By Ivanov's method, it has been established that there are three climatic zones in Bangladesh : (*i*) zone with simple humid climate — western bordering districts of Bangladesh; (*ii*) zone with sufficient humid climate — areas of Bangladesh mainly to the west of 90°E and (*iii*) zone with super humid climate — areas of Bangladesh mainly to the east of 90°E. Almost analogous climatic zones have been obtained by Selianinov's method. By Gorsinkii's method, it has been shown that there are three climatic zones in Bangladesh : (*i*) quasi-maritime climate — southeastern and northeastern hilly areas; (*ii*) climate of the plain land — the central belt of the country, and (*iii*) quasi-continental climate — western bordering districts. By Shever's method, it has been shown that there is only sharp continental type of climate in Bangladesh.

Key words — Methodology, Climatic classification, Climatic zones, Evaporation, Precipitation.

1. Introduction

Classification of the climate of a particular country or an area is regarded as an important task of modern climatology (Alisov *et al.* 1940). By classification, fundamental types of climates and the border of the climatic zones are defined, so that climatic analogue may be obtained. Using such classification of climate, it becomes possible to evaluate the climatic resources of a particular country or an area and hence, an all round attempt to exploit these resources may be done. Being guided by these considerations, an attempt has been made to classify the climate of Bangladesh. There are as many as 25 methods of climatic classification (Alisov *et al.* 1940, Kobisheva and Narovlianskii 1978). In the present paper, only some of these methods have been examined. Moreover, such type of classification of climate may be useful in the development of short as well as long range weather forecasting methods.

Results obtained in the present investigation may be used by the planners of our national economy, specially in the planning of agricultural production.

2. Data

In the present investigation climatological data for 27 years (1951-1977) of 16 stations of Bangladesh (Fig. 1)* have been used. The data have been obtained from Bangladesh Meteorological Department. The data include : mean monthly temperature, mean relative humidity and mean monthly sum of precipitation.

3. Method of investigation

In the present research work the following methods of climatological classifiation have been followed :

* The political boundaries in the base maps used may not be to the scale.

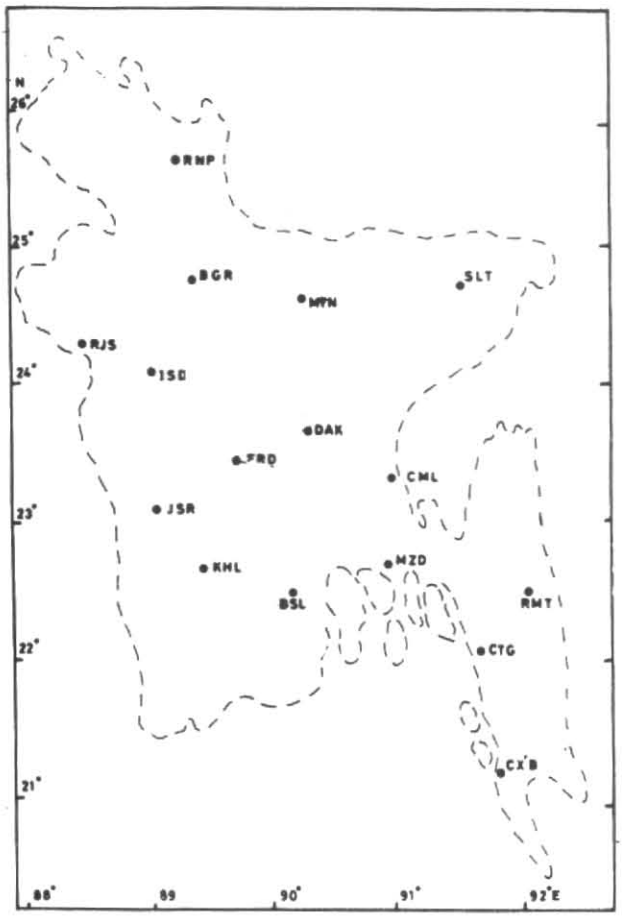


Fig. 1. Location of the meteorological stations of Bangladesh, the data of which have been used in the paper

3.1. *Ivanov's method* — In this method the coefficient of the degree of humidness (K) is defined as (Ivanov 1941, 1956 & 1958):

$$K = \frac{R}{E} \qquad (1)$$

where, R is the quantity of rainfall (mm) for a particular period and E is the quantity of evaporation (mm) for the same period. In climatic classification, mean annual sum of rainfall and mean annual sum of evaporation have been considered. They have been obtained from the monthly values. Evaporation can be measured experimentally or calculated empirically. Experimental data on evaporation for all the mentioned stations of Bangladesh for 27 years are not available. So empirical formula for the calculation of evaporation has been followed. In the present investigation evaporation (mm) have been calculated by using Ivanov's empirical formula (Ivanov 1941):

$$E = 0.0018\,(15 + t)^2\,(100 - r) \qquad (2)$$

where, t is the mean temperature of the month in °C and r is the mean relative humidity (%) of the same period.

Depending on the annual values of K, the classification of climate is made. An area may be regarded as super humid, if the mean value of K is more than 1.5 and sufficient humid, if K is equal to or less than 1.5 and greater than 1.0. An area may be related to simple humid climate if K is less than 1.0, but greater than 0.5 (Ivanov 1941, 1956 & 1958).

3.2. *Selianinov's method* — According to this method, hydrothermal coefficient (*HTK*) has been defined as (Gulinova 1974, Selianinov 1966, Sinissiana *et al.* 1973):

$$HTK = \frac{10\sum P}{\sum t} \qquad (3)$$

where, $\sum P$ is the sum of precipitation (mm) for a particular period; and $\sum t$ is the sum of daily mean temperature (°C) for the same period. This method is valid, when the daily temperature is above 10°C. From the work of Mobassher (1981) it comes out that daily mean temperature in Bangladesh is always more than 10°C and hence this method may be applicable for Bangladesh. In this method mean annual *HTK* is considered. By this method, an area may be related to super humid climate, if mean annual *HTK* is more than 2.0. The climate of the area is sufficient humid, if mean annual *HTK* is from 1.6 to 2.0 and climate is simple humid, if the mean annual *HTK* is from 1.0 to 1.6. If the mean annual *HTK* is less than 1.0, the climate may be termed as the climate of steppe (Gulinova 1974, Selianinov 1966, Sinissiana *et al.* 1973).

3.3. *Gorsinkii's method* — In this method the coefficient of continentality of Gorsinkii is adopted. Following Chatterjee (1959), the coefficient of continentality (C) (in %) for the regions of Geographical India is defined as:

$$C = \frac{1.7A}{\text{Sin}\,\varphi} \qquad (4)$$

A is the amplitude of the mean annual temperature (in °C) and φ is the latitude of the place.

With some modifications (according to the pattern of landscape) following gradings are used to

TABLE 1

Monthly sum of rainfall (mm) and the coefficient of continentality of Shever in Bangladesh

Station	Monthly rainfall												K_o
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Cox's Bazar	9.0	10.6	21.0	90.8	260.8	829.7	1105.1	747.8	368.8	289.7	60.6	10.6	4.0
Chittagong	6.8	14.2	57.8	112.9	235.8	615.6	726.8	533.9	263.7	235.0	63.5	10.4	2.9
Rangamati	4.9	18.2	35.1	75.2	199.6	623.6	629.0	448.3	266.4	206.5	53.6	13.1	3.3
Comilla	10.2	20.4	53.0	136.7	282.6	515.5	512.2	385.2	281.4	220.0	46.0	8.6	2.2
Maijdee Court	11.0	24.1	40.4	113.4	295.2	626.9	679.2	641.0	408.0	299.9	43.0	7.1	2.8
Dhaka	8.8	20.8	56.7	123.4	274.4	365.3	409.6	321.4	253.6	159.7	28.6	5.8	2.0
Sylhet	16.6	45.7	94.7	325.7	565.8	972.7	728.4	683.4	446.1	240.2	30.2	6.8	2.1
Faridpur	8.8	14.6	43.6	141.2	232.8	352.5	392.9	297.6	241.3	191.4	29.6	5.3	1.9
Barisal	12.5	10.9	33.6	84.5	216.9	445.2	430.2	352.9	340.0	221.1	45.0	7.5	2.4
Khulna	9.2	16.3	33.5	72.4	190.2	357.1	407.3	281.4	290.2	169.3	23.2	5.3	2.6
Jessore	10.0	12.4	28.1	59.1	143.9	281.9	322.9	273.4	231.1	143.2	16.4	8.0	2.6
Mymensing	11.5	18.0	40.6	96.6	253.5	483.3	416.2	362.0	305.4	190.5	19.4	2.2	2.4
Rajshahi	14.8	10.5	29.2	40.0	119.2	267.4	365.2	247.1	218.6	119.5	15.7	2.8	3.1
Bogra	9.7	11.1	25.6	55.3	188.4	329.5	381.8	312.9	245.3	163.6	18.1	2.4	2.7
Rangpur	15.3	7.8	33.7	76.7	264.5	494.4	455.4	309.7	234.6	152.4	10.1	0.9	2.7
Ishardi	11.0	17.6	20.8	99.7	214.2	418.5	349.7	316.1	255.7	174.4	18.8	15.4	2.3

classify the climate of Bangladesh (Chatterjee 1959) :

(*a*) Oceanic climate, if C is less than 10%.

(*b*) Continental climate, if C is more than 50%.

(*c*) Transient climate, if C lies within 10-50%.

3.4. *Shever's method* — In this method, the character of the occurrence of precipitation is considered. This method is valid for a region where a sharp contrast in the pattern of the distribution of precipitation in summer and winter prevails (Shever 1976). As there exists a sharp contrast in the distribution of precipitation (Table 1) during winter and summer periods in Bangladesh (Mobassher 1981), this method of classification of climate may be used in the case of Bangladesh. The coefficient of continentality (K_o) is used in this method. Following the nature of the fall pattern of precipitation, this coefficient of continentality may be defined in the case of Bangladesh in the following way :

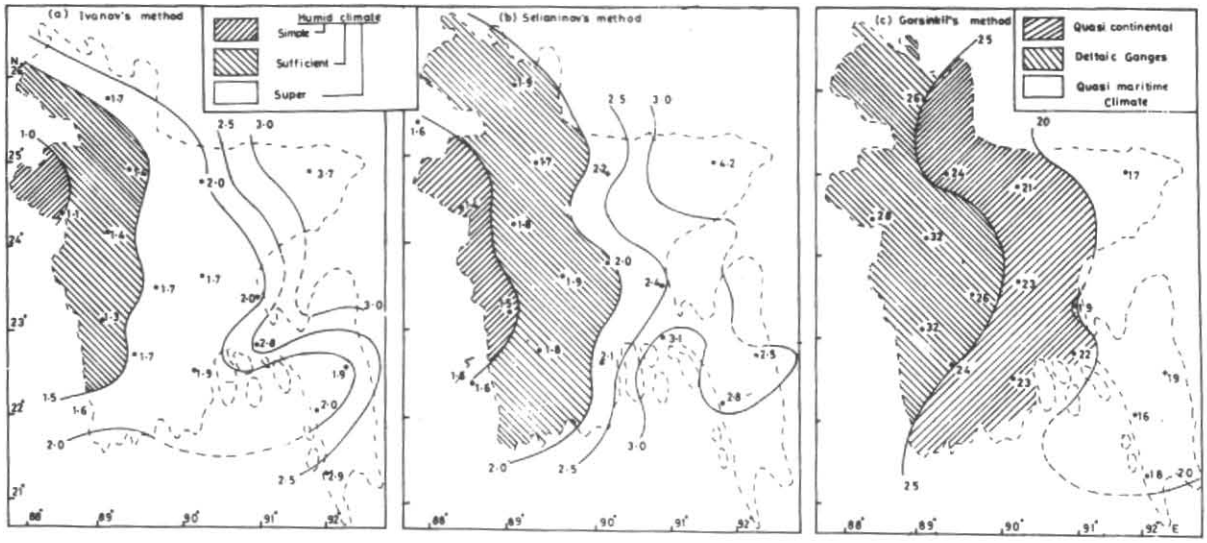
$$K_o = \frac{\sum R_{vi\text{-}ix}}{\sum R_{x\text{-}v}} \qquad (5)$$

where, $\sum R_{vi\text{-}ix}$ stands for the sum of precipitation (mm) during summer monsoon periods (*i.e.*, for the months June to September) and $\sum R_{x\text{-}v}$ stands for the sum of the precipitation (mm) for the rest period of the year, *i.e.*, for the months, October to May.

In this method, a zone belongs to sharp (extreme) continental type of climate, if K_o is equal to, or more than 3.5 and a zone belongs to continental type of climate, if K_o is less than 3.50, but greater than or equal to 1.75. (Shever 1976).

4. Results and discussion

4.1. *Climatic classification by Ivanov's method* — As mentioned in the methodology, evaporation has been calculated by using Ivanov's empirical formula for evaporation. To test the validity of the results, the calculated values of evaporation, obtained by this method, have been compared with those of the observed values for Dhaka. The observed values on evaporation have been collected from the work of Manalo (1976). The calculated and observed values on evaporation may be obtained in Table 2. From the table, it is seen that the calculated values of evaporation for Dhaka are higher in the



Figs. 2 (a-c). Climatic zones of Bangladesh by: (a) Ivanov's method, (b) Selianinov's method and (c) Gorsinkii's method

months. October-April than the observed ones. The values are lower than the observed ones in the months. May-September. The differences may be due to the following causes :

Firstly, the observed values are the average monthly evaporation for a short period. Manalo (1976) in his work did not mention the length of the series of the data. Probably, the average values have been obtained for 5 years' duration, while the calculated values of monthly sum of evaporation have been obtained from the data series of 27 years' duration. Secondly, the effect of wind on evaporation has not been considered in the empirical formula, which may result in the deviation of the calculated values of evaporation from the observed ones. However, the annual sums of evaporation do not differ much (annual sum of evaporation by empirical formula is 1166 mm and observed annual sum of evaporation is 1146 mm for Dhaka). In the calculation of the Ivanov's coefficient of the degree of humidness, the annual sum of evaporation has been considered. As the annual sums of evaporation obtained by empirical formula and by actual observations do not differ much, the Ivanov's coefficient of the degree of humidness has been deducted by using his empirical formula. In it, there may be some errors, of course. Annual mean value of the coefficient of Ivanov (K) in Bangladesh lies in the limit 1.1-3.7 [Fig. 2 (a)]. The values are the lowest in the western part of Bangladesh and they increase slowly to the east.

Following the criteria adopted by Ivanov as mentioned in the methodology of the present paper, it comes out that a very small portion of the western part of Bangladesh (mainly Rajshahi district) may be related to the type of simple humid climate. A great portion of the areas of Bangladesh in between 22°N and 26°N latitudes and to the left of 90°E longitude may be related to the type of sufficient humid climate. So, most of the districts of Rajshahi division belong to this zone. Rest of the areas of Bangladesh (*i.e.*, territory to the right of 90°E longitude) may be related to the type of super humid climate.

4.2. *Climatic classification by Selianinov's hydrothermal coefficient method* — Mean annual value of *HTK* in Bangladesh is found to lie within 1.4 - 4.2. Following the criteria mentioned in the methodology, it is established that a narrow band of the western bordering districts of Bangladesh belongs to simple humid climate. That is, some areas of the districts of Rajshahi, Kustia and Jessore may be related to this type of climate [Fig. 2 (b)]. Another narrow band of territory to the east of this zone (mainly in between 89°E and 90°E longitudes) may be related to sufficient humid climate. The rest of the territory of Bangladesh to the east of this zone may be related to superhumid climate.

The climatic zones obtained by Selianinov's method are almost similar to those obtained by the method of Ivanov.

TABLE 2

Mean monthly temperature (°C) and relative humidity (%) in Dhaka for different months of the year (*source* : Mobassher 1981); observed (*source* : Manalo 1976) and calculated values of evaporation (mm) in Dhaka in different months of the year

Element	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature	18.5	21.2	26.2	28.2	28.9	28.6	28.5	28.5	28.5	27.3	23.4	19.4	—
Relative humidity	75	67	66	71	81	87	87	87	87	84	79	80	—
Calculated evaporation	85	126	160	151	99	67	66	67	67	99	89	70	1146
Observed evaporation	64	83	137	144	154	103	99	87	91	81	68	55	1166

4.3. *Climatic classification by Gorsinkii's method* — Coefficient of continentality of Gorsinkii is found to lie within the limit. 14-32%. Isocontis are quasi-meridional [Fig. 2 (c)]. The following climatic classification may be obtained :

(*i*) Quasi-maritime climate (coefficient of continentality is more than 10% and less than 20%). Most of the areas of Bangladesh to the east of 91°E Long. belong to this type of climate. North-eastern and south-eastern hilly areas may be related to this type of climate.

(*ii*) Climate of the deltaic Ganges or climate of the plain land (coefficient of continentality is in between 20% and 25%). Most of the southern coastal areas. the central portion of the country and northern districts may be related to this type of climate. Most of the areas of Bangladesh in between 89.5°E Long. and 91°E Long. belong to this type of climate.

(*iii*) Quasi-continental climate (coefficient of continentality is more than 25% and less than 50%). Most of the areas of Bangladesh to the west of 89.5°E Long. (excluding south coastal regions) belong to this type of climate. Quasi-continental climate is well expressed in the districts of Kustia. Rajshahi. Pabna and Jessore (where coefficients of continentality are more than 30%).

From the results of the climatic classification by the methods of Ivanov (1941. 1956. 1958). Selianinov (1966) and Gorsinkii. it may be concluded that the change in the climatic zones of Bangladesh mainly takes place from the west to the east.

4.4. *Climatic classification by Shever's method* — Coefficient of continentality (K_o) by the method of Shever (1976) is found to lie in the limit of 1.9 - 4.0 (Table 1) in Bangladesh. Following the criteria described in the methodology. it may be concluded that the climate of the whole of Bangladesh may be defined as continental climate (with respect to the pattern of the fall of precipitation). Only a small area in the south-eastern coastal districts may be related to extreme continental climate.

5. Conclusions

(*i*) According to Ivanov's method. mainly three climatic zones (super humid climate. sufficient humid climate and simple humid climate) are found in Bangladesh. Almost an analogous classification of the climate of Bangladesh has been obtained by Selianinov's method. By these methods. it has also been established that most of the territories of Bangladesh. to the east of 90°E Long.. belong to the super humid climate. The western bordering districts of Bangladesh belong to simple humid climate.

(*ii*) By Gorsinkii's method. 3 types of climate may be seen in Bangladesh. namely. quasi-maritime climate. climate of the plain land and quasi-continental climate. The climate of the western portion of Bangladesh is quasi-continental. The climate of the central region is the climate of the plain land and the climate of the north-eastern and south-eastern hilly areas and their foothills may be termed as the climate of the quasi-maritime type.

(*iii*) The changes in the climatic zones. defined by the methods of Ivanov. Selianinov and Gorsinkii. take place from the west to the east.

(*iv*) By the method of Shever (1976), continental type of climate is mainly found in Bangladesh (with respect to the pattern of the fall of precipitation).

References

Alisov, B. P., Isvekev, B. I., Pokrovskayia, T. V. and Rubineistein, F. S., 1940. Course of climatology (Russian). Hydromet. Publishing House, Leningrad-Moscow. 430 pp.

Chatterjee, S. B., 1959. Climate of India (Translated in Russian). Foreign Literature Publishing House, Moscow. 320 pp.

Gulinova, N. V., 1974. Method of agroclimatological data processing (Russian). Hydromet Publishing House, Leningrad. 149 pp.

Ivanov, N. N., 1941. Zones of the humidness of the world Geology and geography series of the Academy of Sciences of U.S.S.R., No. 3. pp. 261-296 (Russian).

Ivanov, N. N., 1956. Landscape and climatic zones of the world (Russian). I, Academy of Sciences of U.S.S.R. Publishing House, Leningrad. Moscow. 224 pp.

Ivanov, N. N., 1958. Atmospheric humidness of the tropical and adjoining countries of the world (Russian). Academy of Sciences of U.S.S.R., Hydromet. Publishing House, Leningrad, Moscow. 312 pp.

Kobisheva, N. V. and Narovlianskii, G. L., 1978. Climatological processing of meteorological information (Russian). Hydromet. Publishing House, Leningrad. Moscow. 295 pp.

Manalo, E. B., 1976. Agroclimatic survey of Bangladesh. Bangladesh Rice Research Institute, Dhaka. 361 pp.

Mobassher, A., 1981. Synoptico-climatical investigation of Bangladesh (Russian). Ph.D. Thesis, Tashkent State University, 399 pp.

Selianinov, G. T., 1966. Agroclimatological map of the world (Russian). Hydromet. Publishing House, Leningrad, Moscow. 11 pp.

Shever, A. C., 1976. Annual amplitude of the atmospheric precipitation on the territory of U.S.S.R. (Russian). Works of Main Geophysical Observatory, No. 249, pp. 175-182.

Sinissiana, N. L., Goldsberg, I. A. and Strunnikov, E. A., 1973. Agroclimatology (Russian). Hydromet. Publishing House, Leningrad. Moscow. 344 pp.