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Weather and climate of Orissa

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सार – मौसम और जलवायु के ज्ञान की आवश्यकता, विशेषतः पिछड़े क्षेत्र जैसे उड़ीसा राज्य पर अधिक बल नही दिया गया है। कुछ चुने हुए स्टेशनों की जलवायु के विभिन्न पहलू जैसे तापमान, द्वीपीयता, पवन, आर्द्रता, वर्षा, बाढ़ और अनावृष्टि, जलवायु के प्रकार और जल संतुलन को प्रस्तुत किया गया है। इस शोधपत्र में 1920 से 1978 तक के भारत मौसम विज्ञान विभाग द्वारा संग्रहीत आंकड़ों का विश्लेषण किया गया है। स्टेशनों के संजाल में वृद्धि का सुझाव भी दिया गया है।

ABSTRACT. The need for understanding of weather and climate, particularly in a backward region like the State of Orissa cannot be over emphasised. Various climatic aspects such as temperature, continentality, winds, humidity, rainfall, floods and droughts, climatic types and water balance of selected stations have been presented. The paper analysed data collected from India Met. Dep. since 1920 to 1978 as per the availability of records. Increase of network of stations is suggested.

1. Introduction

The State of Orissa located in the sub-tropical belt is situated along the east coast of India and is bounded between Lat. 17° 49′ and 22° 34′ N and Long. 81° 27′ to 87°29′ E. The State has an area 1,55,400 sq km. It is mostly an extensive plateau which slopes gently in the coastal plain along the Bay of Bengal. The *Mahanadi* is the major river of the State and the other rivers are *Baitarani, Brahmani, Rushikulya* and *Subarnarekha. Kotpad* (1825m), *Davagiri* (1365 m) and *Malayagiri* (1170 m) are some important mountain ranges of the State.

2. Physiographic units

The State is highly uneven in topography due to variagate features of mountains and hills. On the basis of physiographic features, the State may be divided into four units: (1) northern plateau constituting Mayurbhanj, Keonjhar and Sundargarh, (2) Central Table land constituting Dhenkanal, Sambalpur and Bolangir, (3) Eastern Ghat region constituting Koraput, Kalahandi and Phulbhani and (4) Coastal tract constituting the Cuttack, Puri, Balasore and Ganjam districts.

3. Temperature

Mean annual maximum temperature distribution over Orissa is shown in Fig. 1(a). From the figure it can be seen that major portion of the State has its maximum temperature ranging from 31° to 33°C. The coastal districts have a mean annual maximum temperature less than 31°C.

Fig.1(b) shows the mean annual minimum temperature of Orissa. A major portion of the State experiences a minimum temperature ranging from 20° to 22° C. A minimum of 17.4°C is found at Koraput and it increases towards southwest part of the State.

Mean annual temperature range is shown in Fig. 1 (c). It can be seen from the figure that as one moves from the coastal area to the interior, the range increases from 7° to more than 12°C.

The hottest month is May during which the temperature increases from the coastal tract (less than 31° C) to the interior land (more than 37° C). A small decrease is, however, found near the northern part of Sundargarh district and southwestern part of Koraput district. The coldest month is December during which the lowest values of temperature are found near Koraput (11.2°C). Central Orissa experiences a value higher than 18° C.

4. Coefficient of continentality

The normal range of temperature (A°C) is taken as a measure of the climatic factor called '*continentality*'.

The coefficent of continentality is denoted by the symbol K and is estimated by using modified formula of Conrad (1950).

$$K = \frac{1.7A}{\sin(\phi+10)} - 14$$

The first half period average and second half period average of the coefficient of continentality

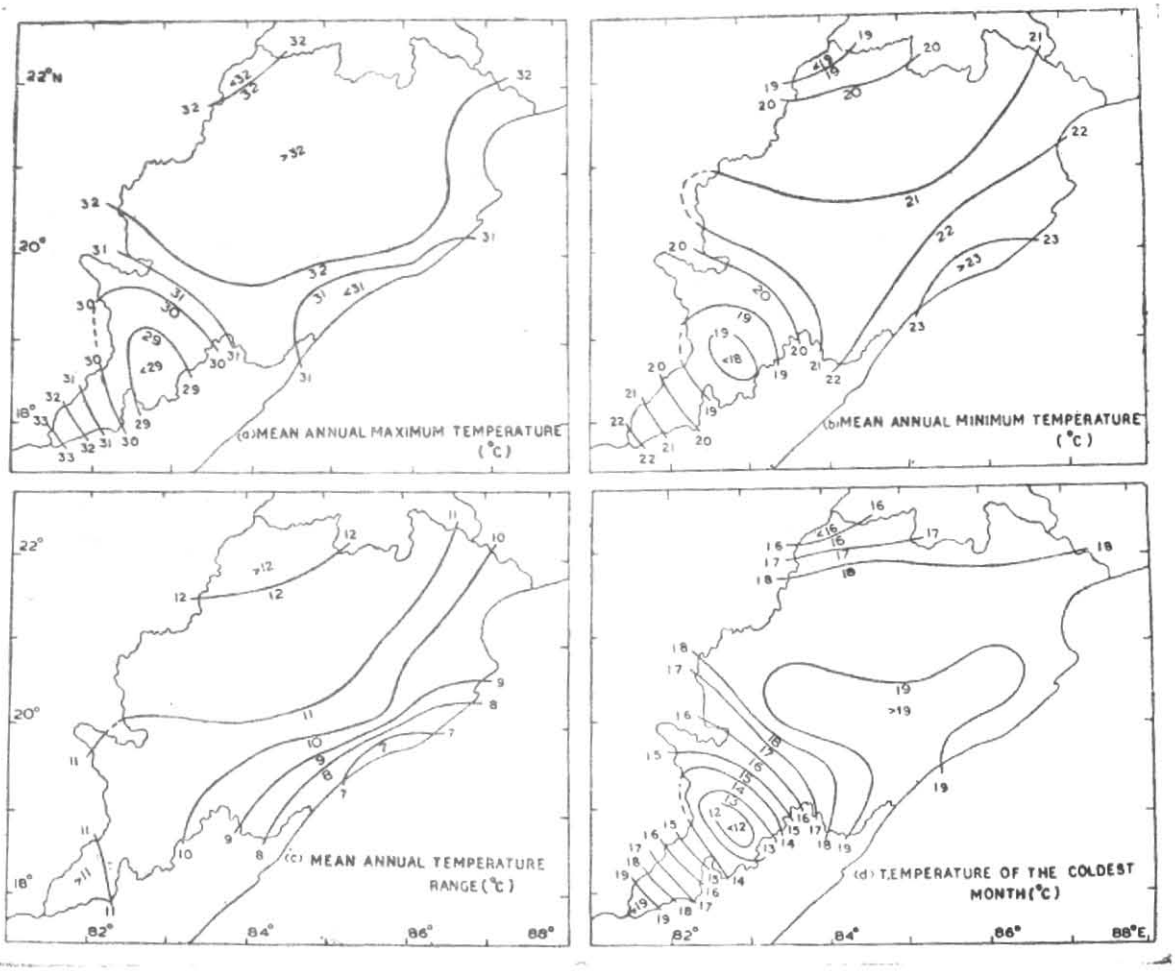

Fig. 1. Mean annual (a) Max. temp., (b) Min. temp., (c) Annual temp. range and (d) Temp. of coldest month in Orissa

TABLE 1

Half period averages of coefficient of continentality (K) in Orissa

Station (Study period)	Lat. (°N)	Normal value of K	Mean for 1st half	Mean for 2nd half	Difference*
Angul (47 years)	20°15′	24.7	22.9	26.4	+3.5
Balasore (54 years)	21°30′	18.4	17.7	19.1	+1.4
Bhubaneswar (27 years)	20°10′	20.1	20.0	20.3	+0.3
Chandbali (49 years)	20°47′	17.9	18.0	17.7	−0.3
Cuttack (59 years)	19°16′	12.6	11.2	13.8	+2.6
Jharsuguda (26 years)	21°45′	25.8	25.7	25.9	+0.2
Koraput (24 years)	18°49′	20.9	18.2	23.6	+5.4
Puri (41 years)	19°48′	7.5	6.8	8.2	+1.4
Sambalpur (59 years)	21°30′	25.5	25.1	25.8	+0.7
Titlagarh (34 years)	20°18′	28.4	25.6	31.2	+5.6

*+ and − sign indicate increasing and decreasing.

of the eleven stations are estimated and presented in Table 1. A high value of coefficient of continentality (28.4) is observed at Titlagarh and minimum (7.5) at Puri.

5. Winds

Mean annual percentage number of days with wind from different directions for the India Meteorological Department stations of Orissa are given in Table 2 (a) and the wind roses at 0830 IST and 1730 IST for these stations are shown in Figs. 2(a) and 2(b).

Mean annual wind speeds at the India Met.Dep. stations in Orissa are given in Table 2(b). It is evident from the table that maximum wind speeds are experienced in the month of May (hot season) by all the stations except Sambalpur at which maximum is recorded in the month of June. Minimum values of wind speed are found in the month of November and December for all stations except Gopalpur which has its minimum value in the month of January.

6. Humidity

The average humidity of the State varies from 57% in the month of March-April to 87% in the month of July and August. Humidity of

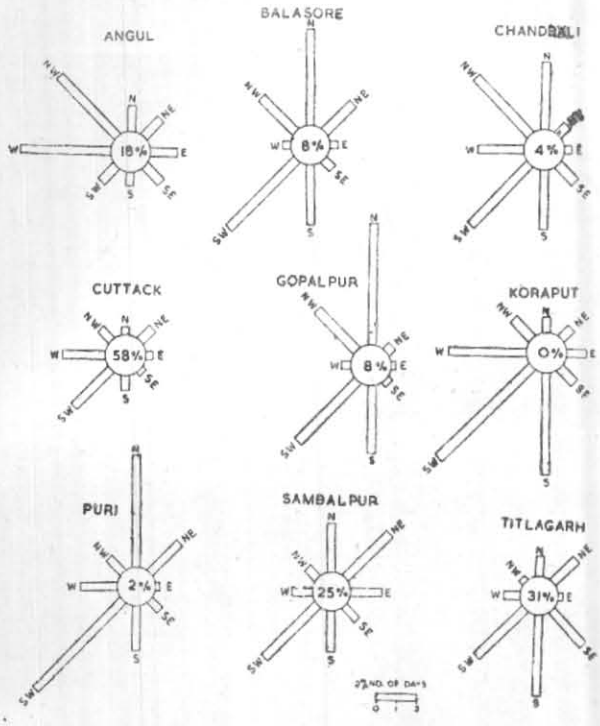

Fig. 2(a). Wind roses in Orissa at 0830 IST

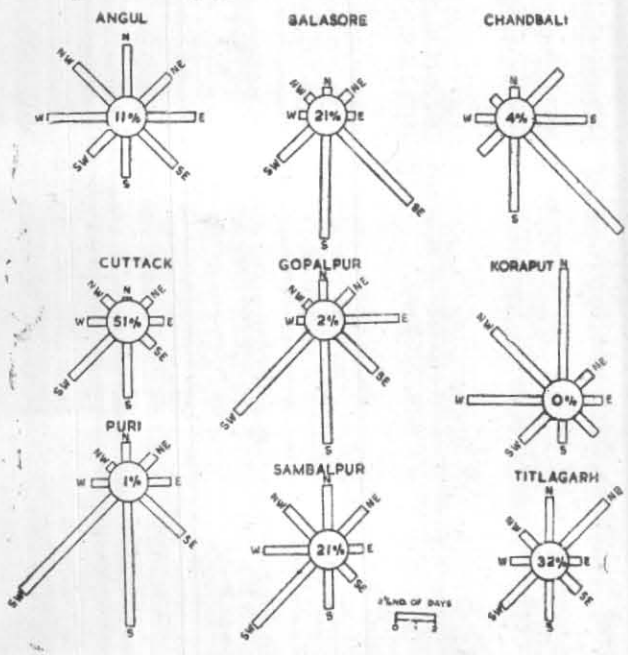

Fig. 2(b). Wind roses in Orissa at 1730 IST

coastal districts (*viz*, Cuttack, Puri, Balasore and Ganjam) remain always high and varies from more than 60% in the month of March-April to 85% in the months of July-August. The inland districts (Sambalpur, Bolangir, Keonjhar, Koraput, Phulbhani) are comparatively drier and the humidity varies from 45-60% during winter.

TABLE 2 (a)

Mean annual percentage number of days of wind

Station		N	NE	E	SE	S	SW	W	NW	Calm
Angul	I	6	6	7	6	4	6	26	21	18
	II	13	10	8	12	10	8	15	13	11
Balasore	I	24	10	2	3	15	24	2	12	8
	II	2	3	2	25	26	11	2	2	27
Chandbali	I	17	3	2	6	15	21	12	20	4
	II	3	12	13	34	18	8	5	3	4
Cuttack	I	2	5	2	1	4	13	11	4	58
	II	1	3	4	4	14	15	5	3	51
Gopalpur	I	31	2	1	1	17	22	3	15	8
	II	5	5	14	13	31	27	2	1	2
Koraput	I	4	4	5	5	26	33	16	7	0
	II	28	5	5	7	6	10	19	20	0
Puri	I	28	10	1	3	11	31	9	5	2
	II	5	5	6	14	31	33	4	1	1
Sambalpur	I	12	15	8	4	10	18	5	3	25
	II	9	8	4	4	10	17	11	10	27
Titlagarh	I	5	8	1	12	20	17	4	2	31
	II	11	16	3	6	10	12	5	5	32

Table extracted from India Met. Dep. Publication : '*Climatological Tables of Observatories in India* (1931-60)'

7. Rainfall

The State of Orissa receives major portion of its annual rainfall during the southwest monsoon season. The southwest monsoon breaks in the second or third week of June and continues till the first week of October. August is the rainiest month. December and January are the driest months.

Rainfall data (1920-1978) of 18 stations are taken for analysis in which 11 stations are within the State and 7 around the border of the State. Fig. 3(a) shows that more than 1500 mm of rainfall is received around Koraput, Sambalpur and Balasore. Southwestern portion of Koraput, a portion of northern plateau and the coastal region of Ganjam and Puri district receive rainfall of less than 1300 mm. Central portion of the State receives rainfall ranging from 1300 to 1400 mm.

Monsoon season (June to September) rainfall of Orissa is shown in Fig. 3(b). Fig. 3(c) shows the rainfall of Orissa State in post-monsoon or winter season (October to February) and the rainfall in the pre-monsoon season (March to May) is shown in Fig. 3(d).

Fig. 3(e) shows the mean annual number of rainy days with precipitation more than 0.3mm. Northern part of the State experiences more than 95 number of rainy days. The number of rainy days decrease from Koraput to Phulbhani and Ganjam districts.

8. Floods and droughts

Successful agriculture and crop yields depend upon a number of factors like floods, droughts, seed quality and agronomic practices etc., out of which flood and drought are due to extreme or scanty rainfall.

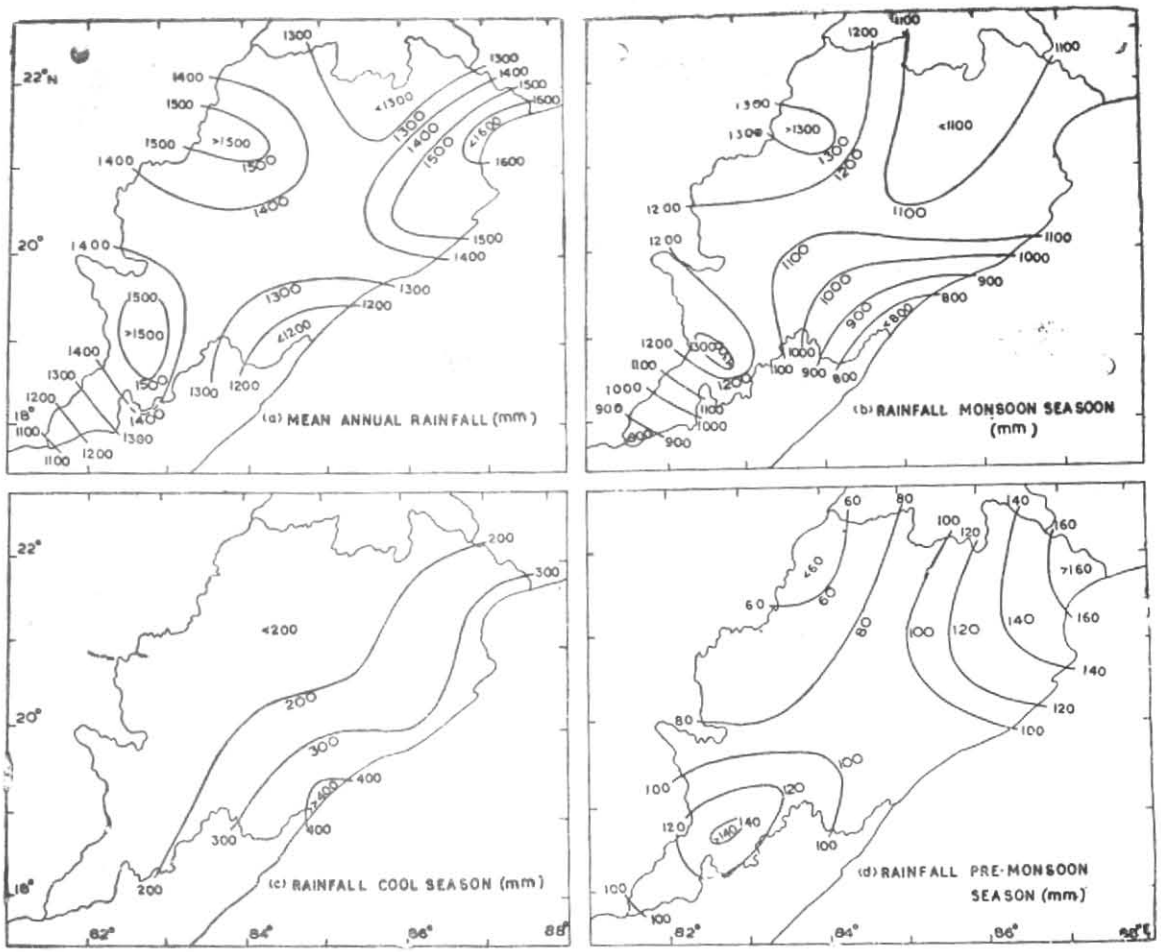

Fig. 3(a-d). Rainfall (mm) over Orissa : (a) Mean annual, (b) Monsoon season, (c) Cool winter season & (d) Pre-monsoon season

TABLE 2 (b)

Mean annual wind speed (kmph) over stations in Orissa State

Station	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Angul	5.4	6.2	7.0	8.0	10.1	9.1	8.1	7.6	6.4	5.6	5.2	5.2	7.0
Titlagarh	2.0	2.4	3.2	4.1	5.3	5.4	4.4	3.5	2.7	2.6	2.1	1.8	3.3
Balasore	4.0	5.5	8.5	11.8	13.5	10.6	10.3	8.8	6.2	4.4	3.8	3.7	7.6
Chandbali	5.7	7.3	9.7	14.5	16.9	12.8	11.2	10.2	8.2	6.1	5.1	5.3	9.4
Cuttack	2.9	3.8	5.6	7.7	9.1	7.2	6.7	6.1	4.8	4.3	3.3	2.6	5.3
Puri	11.9	15.9	20.5	24.0	26.2	23.3	19.7	15.9	12.3	10.2	10.5	10.5	17.8
Gopalpur	9.5	12.8	17.6	22.5	25.4	17.2	17.3	14.5	12.0	10.5	10.4	9.8	15.0
Sambalpur	3.0	3.7	4.3	5.3	6.7	8.0	8.3	7.4	5.5	3.8	3.1	2.6	5.1

Table extracted from India Met. Dep. Publication : '*Climatological Tables of Observatories in India* (1931-60)'.

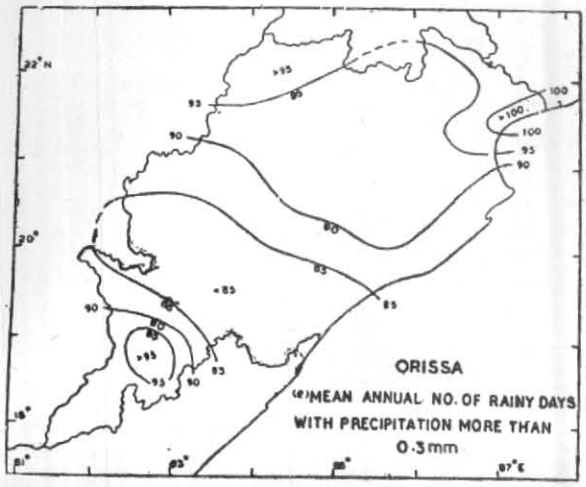

Fig. 3(e)

TABLE 3

Flood and drought years in Orissa State

Station and period of study	Flood years	Drought years
1. Angul (1920-71)	1931(2035), 1961(2109)	—
2. Balasore (1920-66)	1956(2965)	—
3. Bhubaneswar (1952-78)	1958(2434)	—
4. Chandbali (1930-69)	—	—
5. Cuttack (1920-69)	1946(2452), 1956(2372)	1935(692)
6. Gopalpur (1920-72)	1936(2042), 1940(1833), 1942(1816), 1955(1835), 1968(1980)	—
7. Jharsuguda (1955-72)	—	—
8. Koraput (1951-72)	—	—
9. Puri (1932-72)	—	—
10. Sambalpur (1920-72)	1961(2713)	—
11. Titlagarh (1946-72)	—	—

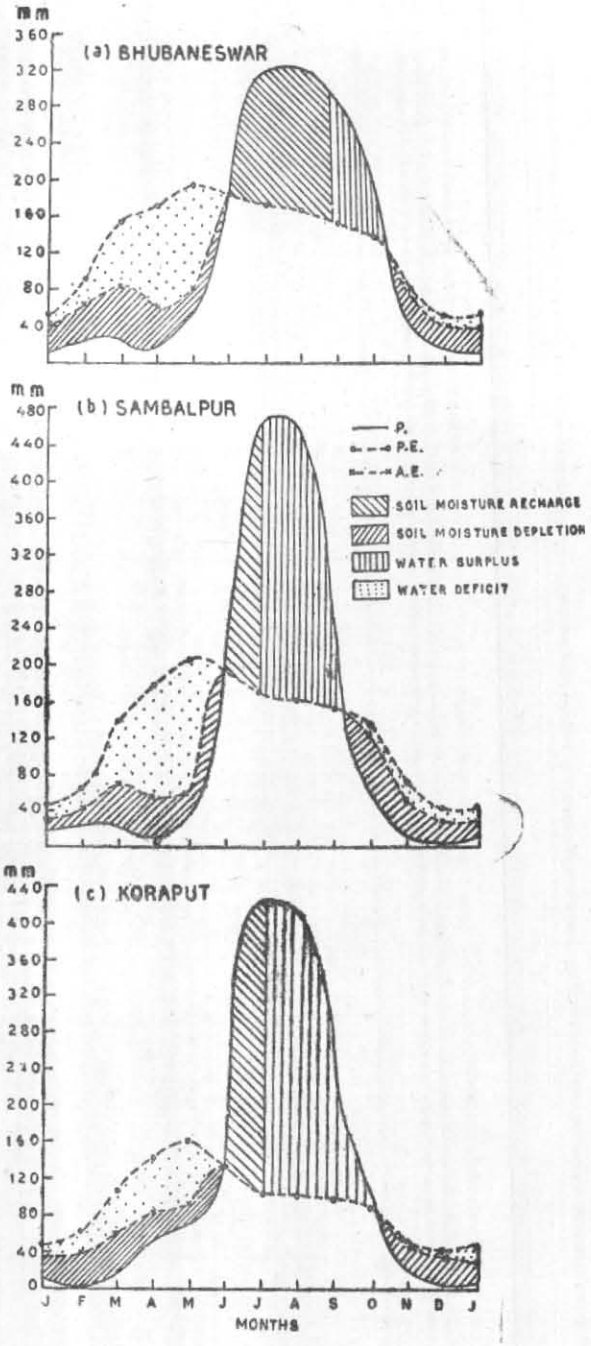

Fig. 4. Climatic water balances of Orissa

In our earlier paper 'Rainfall Variability and crop yields in Orissa State' an attempt has been made to analyse crop yield rates of rainfed dry and fibre crops along with the rainfall regime. The years of occurrence of floods and droughts have been studied by the method of George and Ramasastry, where a flood year is a year receiving rainfall of 150% or more of the normal annual rainfall and drought year is a year receiving a rainfall of 50% or less than that of the annual value. Table 3 gives the flood and drought years in Orissa State reported earlier by Subramaniam and Uma Devi (1979). It can be seen from the Table that the occurrence of floods are by far more frequent than droughts. Droughts are found to have occurred only during one year at Cuttack (1935) and Puri (1957) for the periods in which the rainfall data is analysed.

TABLE 4

Geographical elements and climatic types

Station	I_m %	Summer concentration	Climatic types			
			Moist type	Climates sub-type	Thermal type	Climates sub-type
Angul (20°50′N, 85°06′E, 139 m)	−18.2	35.5	C_1	d	A'_4	a'_5
Balasore (21°30′N, 86°56′E, 20m)	+3.3	35.2	C_2	s	A'_3	a'_5
Bhubaneswar (20°14′N, 82°43′E, 25m)	−7.9	34.1	C_1	s	A'_4	a'_5
Chandbali (20°47′N, 86°44′E, 6 m)	+0.6	34.4	C_2	s	A'_4	a'_5
Cuttack (20°38′N, 85°56′E, 27 m)	−7.7	34.0	C_1	s	A'_4	a'_5
Gopalpur (19°16′N, 84°53′E, 17 m)	−26.9	33.0	C_1	d	A'_4	a'_6
Jharsuguda (21°56′N, 83°59′E, 140 m)	+8.8	36.5	C_2	s_2	A'_3	a'_4
Koraput (18°49′N, 82°43′E, 913m)	+34.0	35.5	B_1	s_2	A'_1	a'_3
Puri (19°48′N, 85°49′E, 6 m)	−15.7	32.8	C_1	d	A'_4	a'_6
Sambalpur (21°28′N, 83°58′E, 148 m)	+1.6	36.5	C_2	s_2	A'_3	a'_4
Titlagarh (20°18′N, 83°18′E, 211 m)	−14.6	34.9	C_1	s_2	A'_3	a'_5

9. Climatic types

In 1948 Thornthwaite introduced the concept of potential evapotranspiration and proposed a climatic classification in 1955. Climatic types of Orissa on moist and thermal regimes along with geographical elements are presented in Table 4. The climatic types of Orissa based on the moist classification comes under three types. Koraput is the only station showing humid (B) type of climate. The remaining stations are either moist sub-humid or dry sub-humid. The interior part of the State is occupied by moist sub-humid type (C_2) and the coastal tract and its surroundings are occupied by dry sub-humid type of climate (C_1).

Thornthwaite has also evaluated the climatic types based on thermal efficency (PE). If the thermal efficiency is 114 cm and above, the climate falls under megathermal (A′) climate. Orissa comes under this megathermal type and there exists four sub-types (A_1', A_2', A_3', and A_4'). A_1' is found in the southern part of Koraput district. A_2' is found in the northern part of Koraput and parts of Kalahandi districts. A_3' is found in the interior hilly region and A_4' in the coastal tract comprising Ganjam, Puri, Cuttack and parts of Balasore district.

The water balance diagrams for Bhubaneswar (dry sub-humid), Sambalpur (moist sub-humid) and Koraput (humid) are presented in Fig.4 for assessing the moisture conditions to determine seasonal surpluses or deficiencies. Water balance of Bhubaneswar shows that soil miosture recharge is found during the period — middle of June to the 2nd week of September and then water surplus follows till the end of October. Water deficit and soil moisture depletion is experienced during the remaining period.

The water balance diagram of Sambalpur shows that soil moisture recharge follows from middle of June to July and then water surplus follows till the end of October.

Koraput shows a surplus from July to the middle of October and a deficiency in other months. The remaining period is found for soil moisture recharge.

10. Conclusions

The above paper is a study based on eleven stations for various periods of record during 1920-1978. It is suggested that more stations, recording climatic data, particularly in the hilly areas and near the Chilka lake will contribute to a better understanding of the weather and climate of Orissa. In view of planning for development it is necessary to have one station in each revenue district in addition to the stations mentioned above to facilitate forecasting and advisory work to the users of the data.

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