Int. J. Exp. Res. Rev., Vol. 4: 51-56 (2016)

International Journal of Experimental Research and Review (IJERR)

ISSN: 2455-4855 *Original Article*

Assessment of climate in Jharkhand : A precipitation and Evapotranspiration regime approach.

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ABSTRACT

Present paper is an attempt to assess the climate of Jharkhand based on the concept of precipitation and trans-evaporation region to Thornthwaite (1955) for that purpose, mean monthly temperature and rainfall data of seven IMD Station of Jharkhand state have been collected for a sustained period (50-100 years) and average water balance conditions of individual stations were estimated by using the Thornthwaite and Mather (1955) water balance technique indices namely Index of aridity (Ia), Index of humidity (Ib) and Index of moisture were computed. Based on the moisture Indices (1m) it is found that the climate of the state is under the influence of two climate types namely, the moist Sub humid (C_2) and the dry sub humid (C_1). In order to understand the seasonal variation of moisture effectiveness within these broad climatic types, the climates were sub divided. The analysis indicated the prevalence of two climatic sub types within the dry sub humid climate (C_1). Further, the Isogram of the percentage of moisture index suggests that the central parts of the experiences moist sub humid types of climate, the extreme north western parts semi and type of climate and the remaining parts experiences dry sub humid type of climate with varying seasonal moisture effectiveness.

Key Words : Isogram, Precipitation Effectiveness, Evapotranspiration, Aridity Index Megathermal, Thermal regime.

Introduction

Climate refers to the average weather and represents the state of the climate system over a period of time. It is often defined as the average condition of weather over a period of time, while weather is considered as day-to-day variations in the atmospheric elements involved. Since numbers of climatic elements such as temperature, rainfall, humidity, wind etc together are responsible to determine the climate, variation in these elements from place to place result in the variations of climate. Thus no two locations on the earth surface experiences similar weather conditions (Carter et al., 1966; Oliver and Hidore, 2003). Miller (1931) expressed that though climatic variations are observed over space and time, some degree of regularity in the combination of climatic elements helps in categorizing climatic types broadly. This type of grouping or classification of climate is useful to understand the nature and distribution of climates in scientific way. Climate largely governs the food habits; clothing, occupation and house type of any

area, thus an understanding about the climatic types and characteristics are of utmost importance. An area which experiences a homogenous set of climatic conditions produces by the combined effect of numerous climatic elements are known as climatic region (Critchfield, 1983)

A number of attempts were made by scientists to classify climates. The earliest attempts of climatic classification initiated by the Greeks as they divided the earth based on thermal characteristics namely, torrid, temperate and frizzed zones (Mcknight, 1984). Later, moisture factors were also included in the Schemes of climatic classification. Linsser (1869) pioneered in using precipitation parameter in classifying climates, as he put forth the notion of moisture index (ratio of precipitation and evaporation) and classified climates into moist and Dry Zones. With his work, a new era of modern climatic classification began as scientists started incorporating rainfall parameter also in their scheme of climate classification. Another landmark in the systematic classification of climates of the world was made by Wladimir Koppen, who recognized the appropriately of plants as an ideal meteorological instrument for the identification and delineation of various climatic zones.

Table 1: Thornthwaite's (1955) Climatic Classification based on moisture index.

Sl. No.	Climatic type	Symbol	Moisture Index (In %)
1	Per Humid	A	100 and above
2	Humid	B^4	80 - 100
3		B_3	60-80
4		B_2	40-60
5		B_1	20-40
6		C_2	0-20
Dry Climates (Im < 0)			
7	Dry Sub humid	C_1	– 33.3 to 0
8	Semi Arid	D	– 66.7 to -33.3
9	Arid	E	– 100 to 66.7

So far, quite a number of schemes of climatic classifications are available based on empirical, genetic and applied approaches. Of these, empirical schemes are outnumbered (Terjung and Louie, 1972).

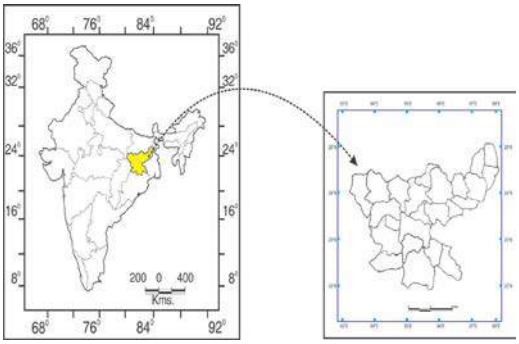
Among the empirical climatic classifications Thornthwaite's scheme of climatic classification became more popular for its rational, conceptualized and myriads of applicability in general and in the fields of ecology, agriculture and water resource development in particular (Hema Malini, 1979; Ayoade, 1983; Subrahmaniam, V.P. and Viswanatham, 1985)

Thornthwaite's climatic classification is based on two parameters namely thermal regime and precipitation regime. Analysis of thermal regime provides the information regarding their available thermal potential required by any vegetation to grow, while moisture regime suggests the availability of moisture to vegetation. It is found that a region may be efficient thermally for vegetation growth but lack of moisture inhibits vegetation growth. Again, the vegetation type and their distribution largely depend upon the moisture availability. For this fact, Thornthwaite out weighted moisture regime over thermal regime approach. Earlier study of climatic classification of Jharkhand based on thermal regime approach has revealed that Jharkhand State possesses a rich thermal potential as it experiences mega thermal (Ac) type of climate. In the present paper, thus an attempt is made to classify the climates of Jharkhand based on moisture effectiveness using water balance techniques formulated by Thornthwaite and Mather (1955).

Study Area

Geographically, the Jharkhand State covers an area of 79,714 km^2 and lies between

latitudes $21^0$58' N to $25^0$18' N and longitudes $83^0$22' E to $87^0$57' E.



The State is characterized with plateaus of different elevations, valleys, scarps, ridges, hillocks etc. Tropical moist deciduous and tropical dry deciduous forests comprise the natural vegetation and are found over hilly landscape, rough terrain, narrow valleys, steep scarps and poorly accessible areas (Sinha and Singh, 2003). The area receives maximum rain (more than 80%) in southwest monsoon season (June to September). The amount of rainfall decreases from 1400 mm in the east to 1100 mm in the west.

Data collection and methodology

The water balance technique of Thornthwaite (1955) has been adopted for the present study. To compute water balance, mean monthly temperature and rainfall data for about 50 to 100 years were collected from the records of India Meteorology Department (IMD) for the seven IMD stations in the State. In addition, data on land use and soil of Jharkhand were obtained from the NBSS & LUP, Nagpur. The soil maps were interpreted to assess the field capacities of the different soils existing in the State.

In water balance procedure precipitation is considered as income, potential evapotranspiration as expenditure and the amount of moisture stored in the soil as a sort of reserve, which may be drawn from the soil during rainless period or scantly rainfall. While comparing potential evapotranspiration and precipitation, if precipitation equals potential evapotranspiration it implies that there is neither a water surplus nor deficiency and the climate is neither moist nor dry.

When precipitation exceeds evapotranspiration, it leads to water surplus and the climate becomes wet or humid. But in the case of less or no precipitation, water deficiency occurs, as rainfall fails to meet the demands of atmosphere in terms of evapotranspiration and the climate becomes dry or arid, Thus, water balance enables to derive monthly actual evapotranspiration (AE), water deficit (WD) and water surplus (WS) of any given area. These elements help in deriving indices namely aridity index (Ia) and humidity index (Ih). Thornthwaite expressed these indices as below

$$Ia = - (WD / PE) \times 100$$

$$Ih = \underline{\ } (WS/PE \times 100$$

where, WD = water deficit, WS = water surplus and PE = Potential evapotranspiration. From these two indices moisture index (Im) may be derived as shown below

Im = Index of humidity (Ih) – Index of aridity (Ia)

Thornthwaite (1955) in his scheme of climatic classification used Index of Moisture (Im), as a basis to demarcate arbitrary boundaries between two major types of climate. The scheme is given in Table 1. to demarcate the variations within the broad categories Thornthwaite had adopted the seasonality of adequate and exceptional moisture conditions. Exceptional condition means, a surplus in dry climate and a deficit in moist climate (Hema Malini, 1992). This type of analysis is very useful to identify the degree of intensity (large, moderate or little) of water deficiency and water surplus in the moist and dry climatic regions respectively.

Thornthwaite's scheme has the limitation to provide explanation for dry climate. Hence, Carter and Mather (1966) have extended the classification and given the appropriate classes to varying degree of dryness. Table - 2 presents the extended classification of moisture effectiveness. For the present study the same method has been followed to derive the moisture effectiveness of Jharkhand State, Finally, based on the index of moisture climatic types of Jharkhand were delineated.

Results and Discussions

(i) Water balance elements

To determine climatic regimes of Jharkhand, several water balance elements namely potential evapotranspiration, actual evapotranspiration, water deficiency and water surplus were computed. The annual distribution of all these water balance elements at individual stations was presented in Table 3 and their spatial pattern is represented in Fig 1. The annual value of potential evapotranspiration indicates that the stage has high thermal potential (TE) which ranges from 1271 mm to 1548mm. The regional distribution shows that the higher values of potential evapotranspiration were concentrated in the southern parts (1548 mm in Jamshedpur and 1532 mm in Chaibasa) while it is relatively lower (less than 1289 mm) in the central parts. The analysis of seasonal pattern indicates that potential evapotranspiration is higher during the southwest monsoon season (659 mm), followed by hot weather season (485 mm), retreating weather season (182 mm) and cold weather season (120 mm). The study revealed that the central part of the State has comparatively less seasonal variations when compared with other parts of the State.

The distribution of average annual actual evapotranspiration values of the State is indicating that the rainfall is always deficient to meet the atmospheric demands (PE) of the State. The eastern parts of the State experiences higher actual evapotranspiration rates whereas, the central parts have lower actual evapotranspiration rates. Analysis of the seasonal pattern shows that the State has maximum actual evapotranspiration during the southwest monsoon (652 mm) and less during cold weather season (93 mm). The analysis of average annual water deficit reveals that acute water deficit condition prevails in the western (427 mm) and southern parts (373 mm) of the State than the central parts (243 mm). The analysis of the seasonal distribution of water deficit shows that except southwest monsoon season all the remaining seasons of the State experiences varying magnitude of water deficit conditions.

Table -2 : Seasonal variations in the indices of aridity and humidity

Moist climates (A, B, C_2)	Aridity index
r Little or no water deficiency	0-10
s Moderate summer water deficiency	10-20
w Moderate winter water deficiency	10-20
s Large summer water deficiency	20+
w Large winter water deficiency	20+
Dry climates (C_1, D E)	Humidity index
d Little or no water surplus	0-16.7
s Moderate winter water surplus	16.7-33.3
w Moderate summer water surplus	16.7- 33.3
s Large winter water surplus	33.3+
w Large summer water surplus	33.3+

Table -3: Station wise annual water balance elements of Jharkhand

Stations	Water balance elements (mm)			
	PE	AE	WD	WS
Chaibasa	1532	1180	352	115
Jamshedpur	1548	1154	394	182
Ranchi	1271	1031	240	439
Hazaribagh	1289	1043	246	251
Dhanbad	1457	1091	366	337
Dumka	1511	1176	341	262
Daltonganj	1512	1085	427	84

Water surplus is not very prominent in Jharkhand region as it is a seasonal phenomenon mostly confined to monsoon seasons especially southwest monsoon

seasons. Annually the maximum water surplus conditions exists in and around Ranchi (439 mm), followed by Dhanbad (337 mm), Dumka (262 mm) and Hazaribagh (251 mm) where water surplus in moderate. The southeastern parts experiences low water surplus ranging between 182 mm to 115 mm. Very low water surplus conditions exist in the northwestern part with minimum of 84 mm.

Table 4: Climatic classification of Jharkhand-Moisture Regime.

Station	Ih	Ia	Im %	Climate type
Chaibasa	7.5	23.0	-15.5	C_1d *
Jamshedpur	11.8	25.5	-13.7	C_1d *
Ranchi	34.5	18.9	+15.6	C_2s**
Hazaribagh	19.5	19.1	+0.4	C_2s**
Dhanbad	23.1	24.8	-2.0	C_1s***
Dumka	17.3	22.5	-5.2	C_1s***
Daltonganj	5.6	28.2	-22.6	C_1d *

C_1d *: Dry Sub humid with little or no water surplus.
C_2s**: Moist sub humid with moderate summer water deficiency.
C_1s***: Dry sub humid with moderate winter water surplus.

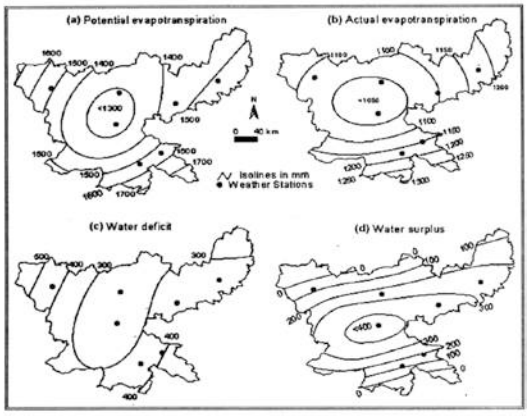


Fig -1 : Spatial distribution of average annual water balance elements of Jharkhand.

Climate classification of Jharkhand

(i) Moisture regime

In order to understand the moisture efficiency of the State spatially, Index of moisture has been computed for all the stations using index of aridity and index of humidity (Table 4). The analysis of the index of moisture in Jharkhand suggests that the State experiences the Im between - 22.6% to +15.6% (Table 4).

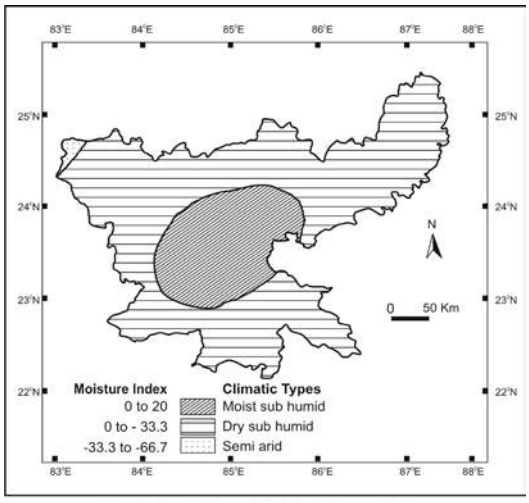


Fig - 2 : Climatic Types of Jharkhand - Moisture Regime

Based on the general scheme of climatic classification (Thornthwaite and Mather, 1955) Ranchi and Hazaribagh in the central plateau region experiences Moist sub humid climate (C_2 ; Im% = 0 to 20%) with + 15.6 and 0.4 of index of moisture percentages respectively. On the other hand the remaining stations namely Chaibasa, Jamshedpur, Dhanbad, Dumka, and Daltonganj categorized under Dry sub humid climate (C_1; Im = 0 to - 33%). The isolines of percentage of Index of moisture drawn to understand the spatial variation indicates that climates of Jharkhand State can be categorized into three types (fig.-2), namely Moist sub humid Climate (Im = 0 to +20%) in the central parts, Dry sub humid climate (Im = 0 to - 33.3%) encircling the central Moist sub humid parts and Semi arid climate (Im = 33.3 to - 66%) towards the extreme northwestern margin of the State.

The sub classification based on seasonal variation of effective moisture, further explains the presence of two sub categories within the Dry sub humid type of climate, namely C_1d type of climate in the southeastern and northwestern parts and C_1s type of climate in the northeastern parts. The

study has indicated that Ranchi and Hazaribagh in the central plateau region possesses maximum thermal as well as moisture potentiality to support prosperous growth of vegetation when comparing with the other region of the State.

Conclusion

Based on the evapotranspiration regime it may be concluded that Jharkhand State is under the influence of three climatic types. The central plateau and pat regions situated on higher elevations of the State has moist sub humid (C_2) type of climate and the adjoining areas are under the influence of dry sub humid (C_1) type of climate, while a small area towards the extreme north western margins of the State is under the influence of semi arid (D) type of climate. The sub classification based on seasonal variation of effective moisture suggests the presence of two climatic sub types within the dry sub humid climate, namely C_1d and C_1s type in the northeastern and southeastern parts respectively. The study of regional distribution reveals that dryness increases towards southeastern and north western parts.

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