

# Analysis of Climates of Jharkhand State – A Thermal Regime Approach

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## Abstract

*Jharkhand State, with forested hills and dissected plateaus and low-lying river valley plains experiences varied climatic conditions across the State. In view of that, an attempt is made in the present paper to classify the thermal climates of Jharkhand based on Thornthwaite's (1955) thermal regime. For that purpose, monthly temperature data of seven IMD stations with variable time scales ranging between 50 to 100 years have been collected to compute monthly Potential evapotranspiration (PE). The analysis of thermal efficiency has indicated that entire Jharkhand experiences Megathermal climate (A') with the thermal efficiency values ranges between 1271 mm to 1548 mm. In order to find out the seasonal variation, percentage of Summer Concentration of Thermal Efficiencies (SCTE) was worked out which indicated that thermal efficiency is highest during summer months. To understand the variation in the intensity within Megathermal climate, it was further classified into four sub categories namely  $A'_1 a'_1$ ,  $A'_2 a'_2$ ,  $A'_3 a'_3$  and  $A'_4 a'_4$ . From the study it was revealed that Jharkhand experiences enormous thermal efficiencies that can support abundant vegetative growth if moisture availability is sufficient throughout.*

## Introduction

The region, which experience homogenous set of weather conditions that results from the combined effects of the lithosphere, biosphere, atmosphere and hydrosphere, is referred as a climatic region. Rotation and revolution, unequal distribution of land and water and unevenness of the surface of the earth has resulted in a large number of climatic variations (Singh and Dhillon, 1998). However, the climate expresses itself differently with varying combinations of intensity. Classification of climates is useful to understand the nature and distribution of climates in a scientific way, which provides

a holistic comprehension about the earth's atmosphere.

Several attempts were made to classify the climates by a number of scientists with different approaches such as empirical, genetic and applied. Empirical classification is based on the observable features of climate and their impact on the ecosystem. Genetic classification is an attempt to organize climates according to their causes. While, applied classifications assist in the solution of specialized problems that involve one or more climatic factors (Oliver and Hidore, 2003). Among the empirical climatic classifications Koeppen's scheme

(1900 and 1936), Thornthwaite's scheme (1948), and Miller's scheme (1965) have gained importance. However, Thornthwaite's classification became popular for its rational, conceptualized and myriads of applicability in general and especially in the fields of ecology, agriculture and water resource development (Ayoade, 1983; Subrahmanyam and Viswanadham, 1985; and Hema Malini, 1993).

Thornthwaite's climatic classification has been derived based on two ecological factors, namely thermal efficiency and moisture adequacy. These factors together determine the growth, development and distribution of an ecosystem. Thermal efficiency is usually influenced by general circulation and geographic location of a place. The earlier studies indicate that patterns of thermal efficiency get altered due to the strong contrast in altitude, oceanicity and continentality of a place (Subrahmanyam and Hema Malini, 1977; Subrahmanyam and Viswanadham, 1985). Therefore, a clear understanding of the thermal condition is essential for a proper land use / land cover planning of a region.

Keeping this in view, an attempt is made in the present paper to delineate the climates of Jharkhand State based on its thermal potentiality.

### **Study Area**

Jharkhand, a newly emerged State of India has been considered for the present study (Fig.1). The State covers an area of 79,714 km<sup>2</sup>, and lies between the latitudes 21° 58' N to 25° 18' N and the longitudes 83° 22' E to 87° 57' E. Physiographically the State comprises several plateaus and dissected

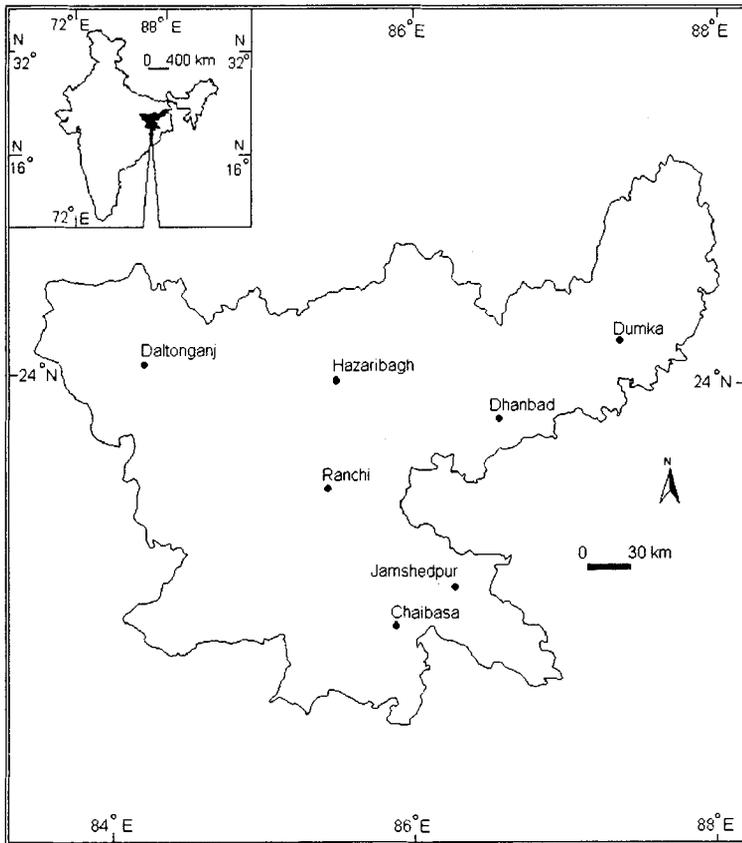
hills with intermittent valleys. Therefore, a marked altitudinal variation occurs in the State that ranges from below 150 m in the eroded river valleys and plains to above 1000 m in the higher plateaus.

Jharkhand experiences both tropical and subtropical climates as the Tropic of Cancer passes through the centre of the State. January is the coolest month with average temperature of 18° C and May is the hottest month with average temperature of 32° C. The State receives rainfall mainly during southwest monsoon season (June to September) from both the branches of monsoon namely the Bay of Bengal and the Arabian Sea. However, eastern portion of the State receive relatively more rainfall as river valleys form natural corridors for the saturated Bay currents (Prasad, 1994).

### **Data Collection and Methodology**

Data on mean monthly temperature were collected from the records of existing seven IMD stations in the State. Table I provides the location and the extent of data of individual stations of Jharkhand for which analysis has been carried out.

Temperature, which is the intensity aspect of heat energy, has a profound ecological significance as often it works as a limiting factor for the growth and distribution of plants and animals (Wilsie, 1962). According to Kochhar (1967) each species have its own minimum and maximum tolerance level of temperature, beyond which, its life activity ceases. Thornthwaite (1931) developed a temperature efficiency index, which was a modification of the temperature summation method. Later, Thornthwaite (1948) coined



**Fig. 1: Location Map of Jharkhand State**

**Table 1 - IMD stations of Jharkhand with Geographical Location**

SL #	Name of the Stations	Location	Period of study
1	Chaibasa	22° 33 N & 85° 51 E	1901-1996
2	Jamshedpur	22° 50 N & 86° 10 E	1924-2000
3	Ranchi	23° 23 N & 85° 23 E	1901-2000
4	Hazaribagh	23° 59 N & 85° 25 E	1933-2000
5	Dhanbad	23° 47 N & 86° 30 E	1941-1990
6	Dumka	24° 17 N & 87° 15 E	1901-1991
7	Daltonganj	24° 02 N & 84° 04 E	1901-2000

a new concept namely Potential evapotranspiration (PE) and defined it as the amount of water loss from an extensive closed homogenous cover of vegetation that never suffers from a lack of water. The potential evapotranspiration, which is, otherwise known as thermal efficiency may be considered as an index of thermal potential of a region.

Thornthwaite (1948) formulated the following formula to compute monthly-unadjusted thermal efficiency values.

$$e = 1.6 (10 t / I)^a$$

Where,  $e$  = mean monthly thermal efficiency in mm

$t$  = mean monthly temperature in °C

$I$  = annual heat index being equal to

$$N = 12$$

$$\sum i_n$$

$$n = 1$$

where,

$i_n$  = mean heat index of the  $n^{\text{th}}$  month given as

$$= (t_n / 5)^{1.514}$$

where,

$t_n$  = mean temperature of the  $n^{\text{th}}$  month

and

$$a = 0.0000006751 (I)^3 - 0.0000771 (I)^2 + 0.01792 (I) + 0.49239.$$

By using the above formula unadjusted values of thermal efficiency can be derived for a normal 30 days month with each having 12 hours of sunshine. Since the number of days in a month varies from 28 days to 31 days, and the duration of sunshine hours ranges from sunrise to sunset depending upon the latitudinal location of the place, the unadjusted values were adjusted with the help of the correction factor. For this purpose, series of tables and a Nomogram

prepared by Thornthwaite and his associates (1957) for various latitudinal locations were used.

For the present study, the same method has been adopted to compute Potential evapotranspiration (PE) values of Jharkhand State. Annual as well as seasonal thermal efficiencies were computed, based on which main and sub climates of the State were delineated.

## Results and Discussion

The analysis of annual thermal efficiencies indicates that the thermal efficiencies range from a maximum of 1548 mm to the minimum of 1271 mm in the State. The region wise distribution shows that the thermal efficiencies are relatively lower in the central region and gradually increase towards the northwestern and southeastern parts. The maximum value of thermal efficiencies being experienced by Jamshedpur, Chaibasa, Dhanbad, Daltonganj and Dumka regions where the values are between 1457 mm and 1548 mm. While, the central parts of the State namely Ranchi and Hazaribagh are experiencing 1271 mm and 1289 mm respectively. The difference in the distribution of thermal efficiencies may be due to the topographical variations of the State where, the central part of the State is an elevated plateau region of 600 m and the eastern and northwestern parts are valley areas with an average elevation of 200 m above sea level. Table 2 provides the annual and seasonal distribution of thermal efficiencies in the State.

The analysis of seasonal thermal efficiencies has revealed that, of all the seasons, Jharkhand State experiences

highest thermal efficiencies during the southwest monsoon season (June-September). The central parts of the State which comprises with Ranchi and Hazaribagh experiences below 600 mm of thermal efficiencies and the remaining parts experiences above 600 mm of thermal efficiencies. The second highest thermal efficiencies prevail during the hot weather season (March – May) with the values ranging between 440 mm and 515 mm. The maximum thermal efficiencies prevail around Jamshedpur and Chaibasa in the southeastern portions of the State during this season with the values above 500 mm. In the remaining parts of the State the thermal efficiencies are below 500 mm. In the retreating monsoon season (October – November) the values ranges between 148 mm and 205 mm, the highest values existing in the eastern and northeastern parts. The thermal efficiencies are comparatively low in the cold weather season (December-February), which ranges between 94 mm and 141 mm. During this season the maximum values are restricted to the southeastern parts of the State i.e. around Chaibasa and Jamshedpur.

Spatial pattern of seasonal thermal efficiencies except in the cold weather season follow the annual pattern in all the seasons with lower thermal efficiencies in the central parts and comparatively higher values in the northwestern and southeastern parts. In the cold season, thermal efficiencies are higher in the southeastern parts and decrease towards north (Fig.2).

Thus, both annual and seasonal thermal efficiency distribution indicates that the central parts of the State exhibit lower thermal efficiencies and the eastern and western parts experience higher values. This

is due to the fact that the thermal efficiency in general is influenced by the elevation of an area. The central parts being the elevated zones experience low thermal efficiencies and the reverse in the case of eastern and western portions of the State.

As already mentioned that though the annual thermal efficiencies indicate that the State experiences abundant thermal potential to support luxuriant growth of vegetation, the study of seasonal distribution of thermal efficiencies is essential and significant to assess the crop potentiality of the region (Subrahmanyam & Hema Malini, 1977). In the agricultural point of view, it can be said that southwest monsoon season is most suitable for agricultural activities as this season experience rich thermal potential as well as abundant monsoon rainfall. On the other hand, in the remaining seasons the areas are either deficient of thermal potential or rainfall and hence agriculture may not be so prosperous. However, crop cultivation can be carried out with the aid of systematic supplemental irrigation during the seasons where rainfall is meagre. On the other hand, during the seasons where thermal potential is minimum, the crops with low requirement of thermal potential can be grown. In the case of Jharkhand, the eastern parts of the State i.e. the areas around Dumka, Dhanbad, Jamshedpur, Chaibasa and the northwestern region (Daltonganj) experiences comparatively higher thermal potential in all the seasons. Which means that these areas are comparatively more suitable for crop cultivation if moisture is not an inhibiting factor.

### **Climates of Jharkhand**

To derive climatic types based on thermal regime, the parameters, namely, the annual

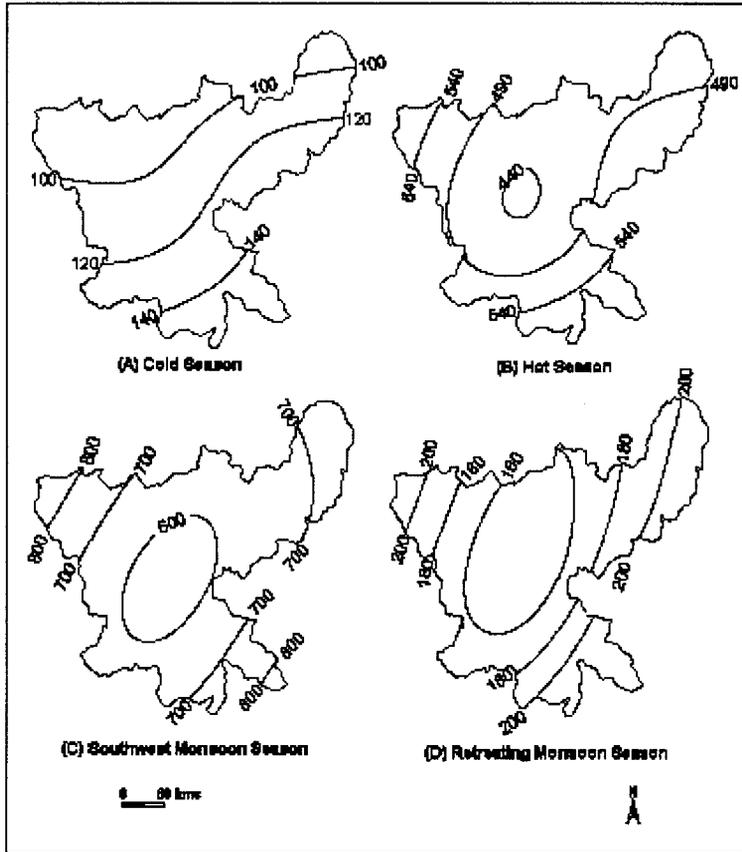


Fig. 2: Seasonal Distribution of Thermal Efficiency in Jharkhand

Table 2 - Seasonal & Annual Distribution of Thermal efficiencies (mm) - Jharkhand

Stations	Seasonal				Annual
	Cold weather (Dec- Feb)	Hot weather (Mar-May)	South-west monsoon (June- Sep)	Retreating monsoon (Oct- Nov)	
Chaibasa	141	515	678	198	1532
Jamshedpur	140	510	693	205	1548
Ranchi	113	440	569	149	1271
Hazaribagh	101	444	596	148	1289
Dhanbad	131	493	647	186	1457
Dumka	122	495	692	202	1511
Daltonganj	94	498	737	183	1512

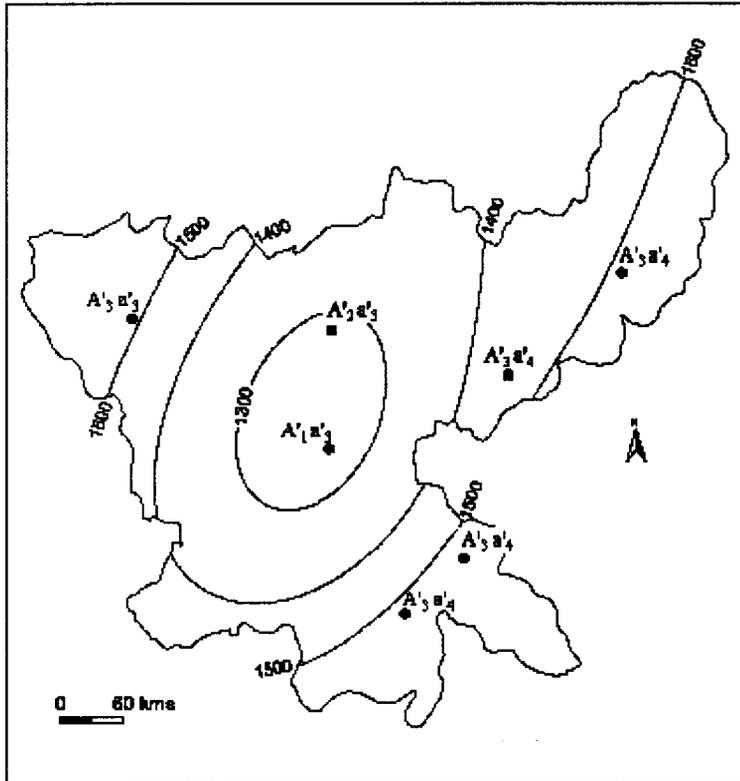


Fig. 3: Climatic Types of Jharkhand State - Thermal Regime

Table 3 - Subdivision of Megathermal type of climate based on TE and SCTE %

TE (mm)	Symbol	SCTE (%)	Symbol
1140-1282	A' <sub>1</sub>	44.6	a' <sub>1</sub>
1282-1425	A' <sub>2</sub>	41.1	a' <sub>2</sub>
1425-1567	A' <sub>3</sub>	38.8	a' <sub>3</sub>
1567-1710	A' <sub>4</sub>	36.3	a' <sub>4</sub>

Thermal Efficiency and Summer Concentration of Thermal Efficiency (SCTE %) have been used for the main classification and the sub-classification respectively. Based on Thornthwaite's thermal regime, it was found that all the seven stations are experiencing Megathermal climate (A') as the annual thermal efficiency values are above 1140 mm (Fig. 3).

However, in order to understand varying intensities within the Megathermal climate (A'), the Megathermal climate has been further sub divided into sub categories. Similarly the entire Jharkhand experiencing below 48.0 percent of SCTE thereby, comes under megathermal (a') sub climate. Again, to have a better understanding of variation within Megathermal sub climate (a') it was further subdivided. Table 3 provides the subdivision of Megathermal climates, for annual as well as seasonal concentration.

As per the above analysis it was revealed that the State experiences three sub types, namely A'<sub>1</sub>, A'<sub>2</sub> and A'<sub>3</sub> within Megathermal

climate (Table 4). The central Ranchi and the Hazaribagh plateau experiences A'<sub>1</sub> and A'<sub>2</sub> sub types of megathermal conditions respectively, while remaining parts of the State comes under A'<sub>3</sub> type. The varying magnitude of SCTE percentage indicates that the State experiencing a'<sub>3</sub> and a'<sub>4</sub> sub climates. The marked contrast in the magnitude of thermal efficiency is due to the contrast in altitude that ranges between 652 m and 611 m in the plateau region to 226 m and 129 m from the mean sea level in the valley regions.

### Conclusion

Based on the study it may be concluded that Jharkhand possesses a rich thermal potential. In general, the thermal efficiency is relatively lower in the central parts of the State than in the adjacent parts. Further, the study suggested that larger seasonal variability of thermal efficiency is higher in the northwestern parts of the State. The study

Table 4 - Categories of Climates of Jharkhand - Thermal Regime

Station	Annual TE (mm)	SCTE (%)	Climatic type
Chaibasa	1532	36.9	A' <sub>3</sub> a' <sub>4</sub>
Jamshedpur	1548	36.6	A' <sub>3</sub> a' <sub>4</sub>
Ranchi	1271	39.8	A' <sub>1</sub> a' <sub>3</sub>
Hazaribagh	1289	40.3	A' <sub>2</sub> a' <sub>3</sub>
Dhanbad	1457	37.3	A' <sub>3</sub> a' <sub>4</sub>
Dumka	1511	37.3	A' <sub>3</sub> a' <sub>4</sub>
Daltonganj	1512	40.2	A' <sub>3</sub> a' <sub>3</sub>

has clearly indicated that the distribution of thermal efficiency in the State has been strongly influenced by the topographical variations.

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