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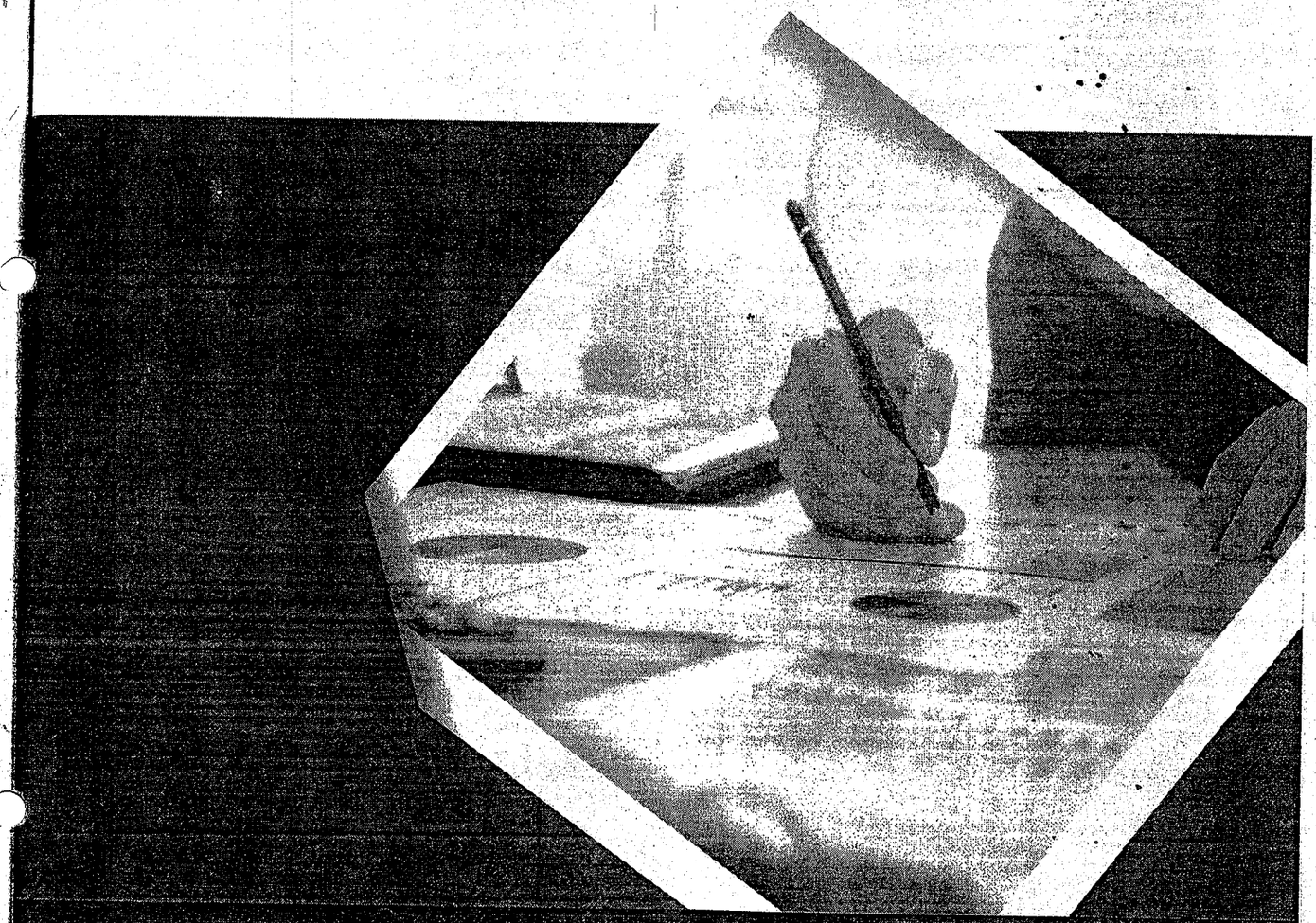

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# Climatic Classification: A Case study of Marathwada Region

Mr.Kishor B. Shinde[1] and Dr. Parag A. Khadke[2]

[1](Asst. Professor in Geography, RajarshiShahuMahavidyalayaLatur, (Autonomous), MS, India)
[2](Professor and Research Guide, HOD of Geography, School Of Earth Sciences,
Swami Ramanand Teerth Marathwada University, Nanded, Maharashtra, India

**Abstract:**

Climatic classification is as device which the multiplicity of atmospheric conditions upon the earth is meaningfully organized.Classification of climate is very significant geographers and other experts. The number of climatic parameters helps to climatologist to identify the climate types of any regions, such as precipitation, rainfall, temperature, humidity, water balance, mount of soil moisture, evaporation etc. In the present study the rainfall, temperature and other parameters data of 8 stations for 37 years (1980 to 2016) have been used. The main objective of this study is to understand the climate of Marathwada. Based on different schemes and indices, like WaldimirKoppen, C.W. Thornthewaite, Trewartha, De-Mortonneetc classification is carried out.

**Keyword:** Climatic Classification, Koppen, Thornthwaite, Thermal efficiency etc.

**Introduction:**

Climatic classification is as device which the multiplicity of atmospheric conditions upon the earth is meaningfully organized. It is also a method of comprehending the variation and distribution of the fundamental elements of climate on our earth as well as their relations to the other phenomena.[1]

The classification of climate is very much useful not only for geographers but also, planner, agriculturalist, meteorologist, Environmentalist, climatologist and other scientists in various fields. Based on the climate farmers can decide or plan about their farm activities such as plowing, selection of crops, time of sowing seeds, taking care of plants etc. The geographers also predict the climate of region through his observation or study of vegetation, soil types, landform animal life, wind speed and direction, amount of moisture in atmosphere, temperature, cloud condition etc. The number of climatic parameters helps to climatologist to identify the climate types of any regions, such as precipitation, rainfall, temperature, humidity, water balance, mount of soil moisture, evaporation etc.

At the local and global level many scholars, meteorologists and climatologists classified the climate, based on different schemes and indices, like WaldimirKoppen, C.W. Thornthewaite, Trewartha, De-Mortonne etc. The WaldimirKoppenand C.W. Thornthewaites classification schemes are widely acceptable and used for classification of climate.

***Study region:***

The present research work is carried out for Marathwada region of Maharashtra state in India. The study region lies in upper Godavari basin which extends from 170 35' north to 20040' north latitude and 74040' east to 78019' east Longitude. The study region covers 64434 sq. km. which is 20.95% of states area. Population of the region is 1.87 cores (2011). The study region has been divided in eight districts for administrative purpose with 76 tahsils. The region characterized by Deccan trap mostly found basalt rock. Major part of region covered by deep black soil, it formed from basalt rock. The climate of study region is typical hot and dries with high temperature. It ranges from 200C to 400C some time it goes more than 400C in summer and also it falls down below 200C in winter season. The study region receives 771.80mm. average annual rainfall. It receives from south western monsoon winds. Near about 70% rainfall receives during June to September i.e. monsoon season.

 

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***Objective:***

The main objective of this research is to understand and characterize the Climate of Marathwada region of Maharashtra State.

***Data and Methods:***

Classification is carried out through various climatic schemes and indices- WaldimirKoppen, C.W. Thornthewaite, Trewartha, De-Mortonne etc. by using Aridity, Moisture, Summer Concentration indices.

The rainfall and temperature data is gathered from IMD and Hydrological Project, Nshik for the period of 1980 to 2016

The IDW method is used for computing spatial variation of intensity through Arc GIS software

***Analysis and Discussion:***

Hence in the present study Koppens and Thornthwaites schemes are used for classification of climate in Marathwada region are as follow.

**a) Cliamatic classification according to Koppens Scheme:**

German botanist and climatologist WaldimirKoppen introduce the scheme of climatic classification. It was based on temperature of coldest and warmest month and precipitation of wettest and driest months.[2] After that he revised it in 1918 and 1936. In the revised scheme he used capital Alphabets (A, B, C, D, E, and H) for major categories. Again he used small letters for dub class of climate which is particularly based on rainfall and temperature (f, s, t, e etc).

In this study rainfall and temperature data of 37 years i.e. 1980 to 2016, have been used. It is observed that the entire study region belongs to 'AW' type of climate which is represent that the "Tropical savanna, hot and Seasonal Dry climate in winter Season". The main characteristics of this climate is monsoon deciduous forest and the temperature of coolest months is more than $18^0$C. the study region experiences, the temperature in the month of May is more than the $18^0$C but on the other hand in coldest month it is below than that. The rainfall in driest month is less than 10-25 mm and most of rainfall occurs in monsoon (June to September) seasons.

Table. No. 1 Climatic Classification according to Coppen's Method[3]

| Station | CLASS | Climate Type |
|---|---|---|
| A'bad | Aw | Tropical Savanna, hot, seasonal dry in winter |
| Beed | Aw | Tropical Savanna, hot, seasonal dry in winter |
| Hingoli | Aw | Tropical Savanna, hot, seasonal dry in winter |
| Jalna | Aw | Tropical Savanna, hot, seasonal dry in winter |
| Latur | Aw | Tropical Savanna, hot, seasonal dry in winter |
| Nanded | Aw | Tropical Savanna, hot, seasonal dry in winter |
| O'bad | Aw | Tropical Savanna, hot, seasonal dry in winter |
| Parbhani | Aw | Tropical Savanna, hot, seasonal dry in winter |

**b) Climatic Classification According to Thorntwaite's Scheme:**

In 1931 C.W. Thorntwaite, American climatologist introduces the scheme for climate classification. After that in 1948, he improved previous scheme by introducingwater balance concept. The first scheme was nearly similar to Koppens scheme, but next scheme is different from first scheme, in this scheme the computed the comparison between potential evapotranspiration with precipitation and opted Moisture

 

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Indix. Again Mather and Thorntwaite modified this scheme and was determined by Moisture Index, thermal efficiency Index and summer Concentration Index in 1955. Subrahmanyam (1956) and Carter (1954) classified Indian Climate in the 6 region based on Thornthwaite Scheme and 5 thermal efficiency types.

In the present study, according to Thornthwaiteclimatic classification scheme the following Indices have been performed.

1) Moisture Index,
2) Thermal Efficiency (Temperature Efficiency) Index,
3) Summer Concentration Index.

**1) Moisture Index:**

According to Thornthwait and Mather moisture Index is required for identification of humid region. The following equation is applied for computation of moisture index.

$Im=100((P/PE)-1)$

Where, Im= Moisture Index, P= Mean annual Precipitation and
PE= Annual Potential Evapotranaspiration.

The following table no.2 shows the classification scheme based on moisture index and their Alphabets respectively according to Thorntwait and Mather. It is observed that the moisture index range from -21.17 to 6.77. the Aurangabad , Jalna, Beed, Osmanabad, Parbhani and Laturdistricts represent with negative value like -21.17, -19.14, -16.16, -15.25, -3.5 and -1.52 respectively. The district are belongs to 0 to -33 Index class and represent 'Dry Sub humid Climate', with C1 letter.

Table no.2 Scheme of Moisture Index and Humidity Province[4]

| Moisture Index | Humidity Province | Letter |
|---|---|---|
| 100 Above | Pre-Humid | A |
| 80 to 100 | Humid | B4 |
| 60 to 80 | | B3 |
| 40 to 60 | | B2 |
| 20 to 40 | | B1 |
| 0 to 20 | Moist sub Humid | C2 |
| (-33) to 0 | Dry Sub Humid | C1 |
| (-66) to(- 33) | Semi-arid | D |
| Below (-66) | Arid | E |

The Nanded and Hingoli districts have positive moisture index value by 6.77 and 5.63 accordingly. It indicates that sub humid climate and represent by C2 letter.

**2) Thermal Efficiency (TE) and Thermal Regions:**

Thermal efficiency or temperature efficiency Index represents the present energy proportion at any places. It is one of the parameter for climatic classification. The region can be classify in to megatherm, mesotherm, microtherm, Tundra and frost according to the Thermal Efficiency Index value.

$TEI=\sum 12\text{month of}(t-32/4)$

Whereas, TEI= Thermal Efficiency Index, $\sum 12$= Sum of annual Temperature,
T= Monthly temperature in fahrenheit

 

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Table no. 3 Scheme of Thermal Efficiency Index[5]

| TE (cm) | Thermal Province | Letter |
|---|---|---|
| 114 and above | Megathermal | A' |
| 99.7 to 114 | Mesothermal | B'4 |
| 85.5 to 99.7 | | B'3 |
| 71.2 to 85.5 | | B'2 |
| 57 to 71.2 | | B'1 |
| 42.7 to 57 | Microthermal | C'2 |
| 28.5 to 42.7 | | C'1 |
| 14.2 to 28.5 | Tundra | D' |
| Below 14.2 | Frost | E' |

It is found that the Thermal efficiency Index value ranges from 138.98 to 149.04. hence the whole study region belongs from megathermal climate type.

**a) Summer concentration Index of Thermal Efficiency:**

It is another scheme of climatic classification is introduced by Thornthwait. It is based on seasonal variation or concentration of temperature. It is used for seasonal climatic classification particularly. The summer concentration Index create relationship between the total potential evapotranspiration or thermal efficiency types and it's expected summer concentration of potential evapotranspiration[6]. The seasonal variation of potential evapotranspiration is small at the equator. Since the variations in temperature there are small, no season can be called summer, and the sum of the potential evapotranspiration of any 3 consecutive months will be roughly 25% of the annual total. In the case of Polar Regions where the growing season is within the 3 summer months, the p potential evapotranspiration of these months willconstitute 100% of the total. The summer concentration of the potential evapotranspiration thus lies between these limits and gradually rises from 25% to 100% with the increase in latitude owing to an increase in the length of midsummer days and increase in the length of winter. The followingclimatic subdivisions have therefore been suggested in terms of summer concentration of PE values[5].

SCITE=ST/AT*100

Whereas, SCITE= summer concentration Index of Thermal Efficiency,
ST= Total Temperature of Summer Months
AT= Sum of Annual Temperature

Table No. 4 Climatic Classification of Marathwada

| Station | Moisture Index | Humidity Provience | Index | Thermal Efficiency | Thermal Proveience | Summer Concentration | Climatic Types |
|---|---|---|---|---|---|---|---|
| A'bad | -21.17 | C1-Dry Sub Humid | 1 | 138.98 | A'-Megathermal | 52.82 | b'3 |
| Beed | -16.16 | C1-Dry Sub Humid | 1 | 144.85 | A'-Megathermal | 52.41 | b'3 |
| Hingoli | 5.63 | C2-Moist Sub Humid | 2 | 149.04 | A'-Megathermal | 52.33 | b'3 |
| Jalna | -19.14 | C1-Dry Sub Humid | 1 | 144.87 | A'-Megathermal | 52.34 | b'3 |
| Latur | -1.53 | C1-Dry Sub Humid | 1 | 147.59 | A'-Megathermal | 51.98 | b'3 |
| Nanded | 6.77 | C2-Moist Sub Humid | 2 | 148.80 | A'-Megathermal | 52.56 | b'3 |
| O'bad | -15.25 | C1-Dry Sub Humid | 1 | 143.64 | A'-Megathermal | 51.79 | b'3 |
| Parbhani | -3.50 | C1-Dry Sub Humid | 1 | 146.27 | A'-Megathermal | 52.83 | b'3 |

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**Climatic Classification based on Aridity:**

Climate Aridity is also one of the Schemes to understand the climatic situation of any region. The word aridity expresses a deficiency of water resulting from either insufficient precipitation or from excess loss of water as compared to the water supply.[7]

The aridity can be measure based on precipitation and temperature, precipitation and evaporation, number of dry days, precipitation and evapotranspiration ratio.

The present study adopts precipitation and temperature based methods, which are introduced by Lang's and De-Mortonne.

**a) Lang's Rain Factor:**

The Lang's Rain factor Index is evaluated the relationship between natural vegetation and climate. It is also referred as Precipitation-Temperature (P-T) ratio. Based on P-T ratio humidity region may classify as fallow, by using following formula.

Rain Factor=Annual Precipitation (mm)/Mean Annual Temperature (°C)

The effectiveness of rainfall efficiency is more important to agriculturalist, hydrologists, civil engineers, Irrigational planners, Geo-hydrologists, Hydro-electrical Engineers etc. in relation to agriculture and climatology the assessment of rainfall effectiveness is computed in terms of meeting crop water need, an output and production per unit of water and financial returns and also assess the other meteorological variables. The following table no. 6 shows the scheme of Rain Factor.

The following table no. 5 indicates the picture of rainfall through the Rain Factor. It is observed that the ratio is between 25.10 % to 31.29 %. Hence the whole Marathwada region experiences the 'AS' type or 'Semi-Arid' Climate type.

Table no.5Climatic Classification of Marathwada by LANG'S Method

| Station | Mean RF (mm) | Mean Temp.(°C) | Rain Factor | Climate Types |
|---|---|---|---|---|
| A'bad | 656.7 | 25.74 | 25.52 | AS-Semi Arid |
| Beed | 693.1 | 26.82 | 25.84 | AS-Semi Arid |
| Hingoli | 863.5 | 27.60 | 31.29 | AS-Semi Arid |
| Jalna | 673.4 | 26.83 | 25.10 | AS-Semi Arid |
| Latur | 804.7 | 27.33 | 29.44 | AS-Semi Arid |
| Nanded | 859.4 | 27.56 | 31.19 | AS-Semi Arid |
| O'bad | 694.9 | 26.60 | 26.13 | AS-Semi Arid |
| Parbhani | 792.9 | 27.09 | 29.27 | AS-Semi Arid |

**b) De-Mortonnes Aridity Index:**

It is the modified version of Lang's Rain factor Ratio. De-Mortonne's Aridity Index also based on an annual precipitation and mean annual temperature. It is employed by De-mortonne in 1926 to delimit different vegetational zones of the earth and also used to climatic classification in France. The following equation is used to evaluate the Aridity Index Value.

$I_A = P/T+10$

Where, $I_A$=Aridity Index, P=Mean monthly Rainfall (mm),

T= Mean annual Temperature ($^0$C),

10= Constant

 

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Table no.6Aridity Index of Marathwada Region

| Station | Mean RF (mm) | Mean Temp.(°C) | T-10 | Aridity Index |
|---|---|---|---|---|
| A'bad | 656.7 | 25.74 | 35.74 | 18.38 |
| Beed | 693.1 | 26.82 | 36.82 | 18.82 |
| Hingoli | 863.5 | 27.60 | 37.60 | 22.97 |
| Jalna | 673.4 | 26.83 | 36.83 | 18.29 |
| Latur | 804.7 | 27.33 | 37.33 | 21.56 |
| Nanded | 859.4 | 27.56 | 37.56 | 22.88 |
| O'bad | 694.9 | 26.60 | 36.60 | 18.99 |
| Parbhani | 792.9 | 27.09 | 37.09 | 21.38 |

Computed by researcher

The above table no.6 recorded that the rage of aridity index in Marathwada region is 35.74 to 37.60. So the entire Marathwada region belongs to 35-55 aridity index class it represent 'Very Humid' type of climate.

**Conclusion:**

The present research paper carried outs the classification of climate in Marathwada region. As per Koppens methods the whole region belongs from 'AW' type climates it represents Tropical Savana hot dry in winter climate. The Thornthwaites scheme represents C1 Dry sub humid climate in far east over Nanded and moist sub humid over A'bad, Jalna, Beed, O'bad, Latur, Hingoli and Parbhani districts. The thermal efficiency index denotes meghathermal climate throughout the region. De-martonne's scheme shows the semi dry over A'bad, Jalna, Beed and O'bad districts and Mediterranean type of climate over Hingoli, Nanded and Latur districts.

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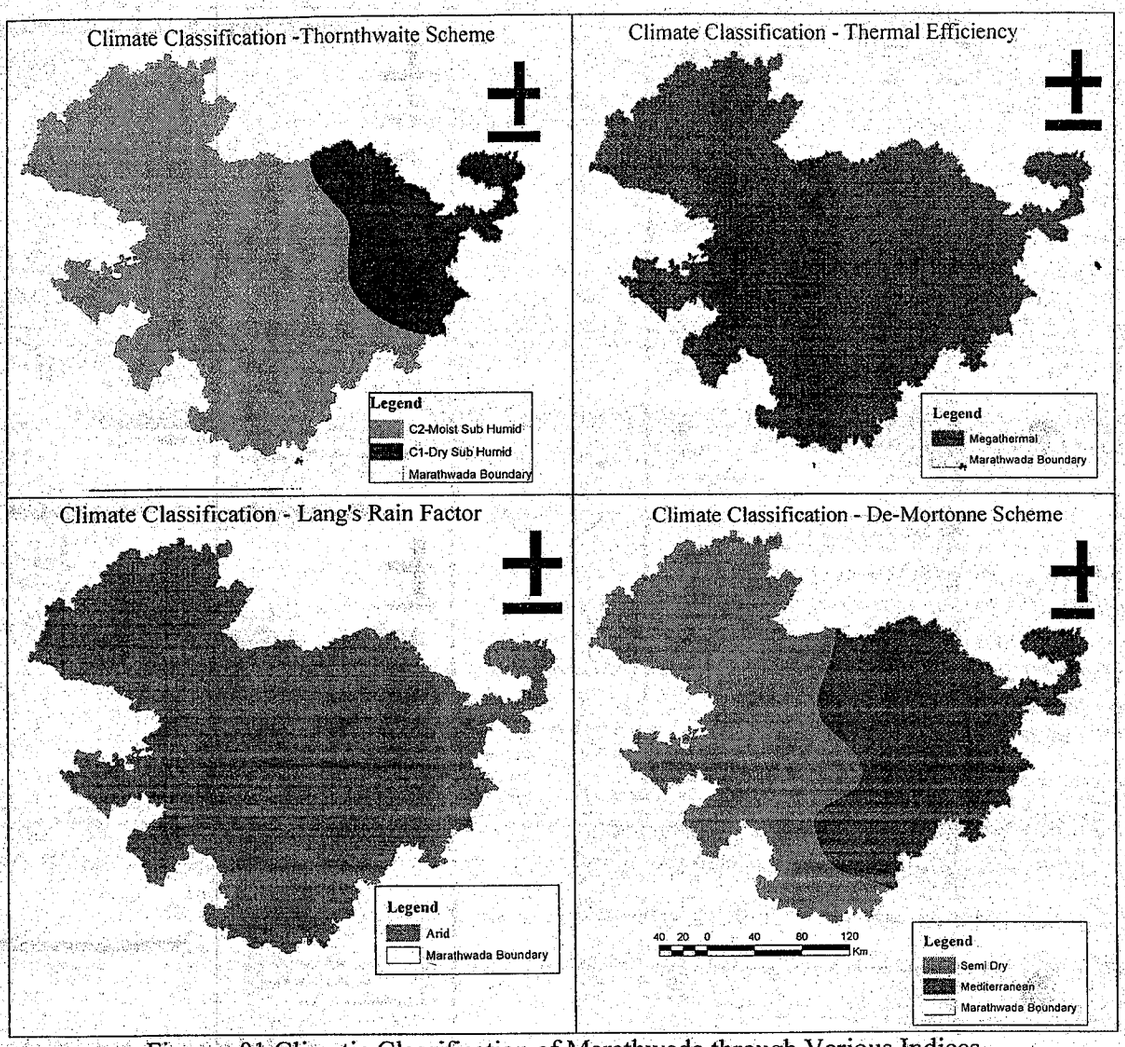


Fig. no. 01 Climatic Classification of Marathwada through Various Indices