Peer Reviewed International Research Journal of Geography
Maharashtra Bhugolshastra Sanshodhan Patrika
ISSN : 0971-6785 {Impact Factor 4.567 Renew (IIFS)} Vol. 38, No.1, Jan-Jun 2021. pp 54-63

Distribution Of Rainfall In Rain Shadow Zone Of Maharashtra State

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Abstract

The region lying on the leeward side of the mountain getting little rain is called Rain Shadow Region (NIOS Geography, p.226) (don't give reference in abstract section). Knowledge of rainfall and its distribution is an important for efficient management of water resources, agriculture, economical activities of the people and diverse flora and fauna inhabiting in the study region. Rain shadow areas have chronic deficiency of water and these areas are highly prone to meteorological and agricultural droughts. In present paper the analysis of monthly, seasonal and annual rainfall data of 120 rain guage stations of rain shadow zone of Western Ghats of Maharashtra state has been done for the period of 1965 to 2016 by using mean and standard deviation methods. Excel was used for computing rainfall data and Arc-GIS software was used for geographical maps. It is observed with the help of average monthly maps of study region that trend of monthly rainfall from January to December moves in a clockwise direction. The total average annual rainfall of five decades of the study region is (873.65mm). Gaganbawada is the highest rainfall station in the study region, which receives (5382.84mm) average annual rainfall, it is sextuple than the average annual rainfall of the study region. Whereas, Sangamner is the lowest rainfall receiving station having average annual rainfall is (422.11mm), which is almost double less than average annual rainfall of the study region.

Keywords: *Distribution of rainfall, rain shadow zone.*

1) Introduction:

Water in liquid or reliable systems falling to the earth is called precipitation (not clear). Rain is the precipitation of water in the liquid state. Foster defined precipitation as "It is deposition of atmospheric moisture and is the most important phase of the hydrological cycle." The distribution of rainfall is undoubtedly complex in the world. Latitude, temperature, moisture, mountain barriers, atmospheric disturbances, movement of air masses, frontal activity, differential heating of land and ocean are some of the factors involved in causing rainfall.

Several researchers have studied the distribution of rainfall from global to local level (Sinha, 1952; Hariharan and Sajnani, 1959; Lalita Devi 1980; Saha and Saha, 1981; Mukherjee and Sinha Ray, 1983; Sexena and Agrawal, 1988; Gadgil et al, 1998; Patwardhan and Asnani, 2000; Swami et al., 2013; Sawant et al., 2015; Gunjal, 2016; Sasane 2016).

Sinha (1952) studied the distribution of rainfall in India and Pakistan. **Dhar et al. (1977)** attempted to study the rainfall distribution over Indian subdivisions during the wettest and the driest monsoons of the period (1901-1960). This study found that during the 60 years, 1917 was the wettest year and 1918 the driest year. **Patwardhan and Asnani (2000)** explained with the help of average daily rainfall (1971-1980) that mesoscale distribution of summer monsoon rainfall near the Western Ghats separately for strong and for weak monsoon condition. Also, showed the rainfall increases rapidly from the Arabian Sea coast close to the maximum height of the Western Ghats. **Yadav et al. (2018)** explained based on 60 years (1901-1960), rainfall data consist of 31 subdivisions of west Rajasthan. This region received the lowest mean annual rainfall of 29.5 cm and a mean monsoon rainfall of 26.4 cm, followed by Saurashtra & Kutch, Haryana, Punjab, East Rajasthan, Royalseema, North interior Karnataka, Telangana, Madhya Maharashtra and Marathwada (all less than 100 cm). **Sawant et al. (2015)** analyzed the distribution, variability and trends in rainfall and observed a minor reduction in annual rainfall over the Cauvery river basin during the 20th century (1901-2002). **Ratna (2012)** analyzed daily rainfall of 329 rain gauge stations data over Maharashtra state for the 11 years

from 1998 to 2008 and found that seasonal rainfall is maximum over the Konkan region followed by the eastern Vidharbha region. In contrast, Marathwada and Madhya Maharashtra as a rain shadow zone receive less rainfall and these low rainfall subdivisions, Marathwada and Madhya Maharashtra, show high rainfall variability.

2) Need of the study:

After all, above reviews, it is observed that the distribution of rainfall in the rain shadow zone of Maharashtra State has not been studied geographically. Hence, this paper constructed monthly, seasonal and annual rainfall distribution for the rain shadow zone of Maharashtra State with the help of 52 years (1965-2016) statistical rainfall data of 120 rain gauge stations of 15 districts within the study region

3) Study Area:

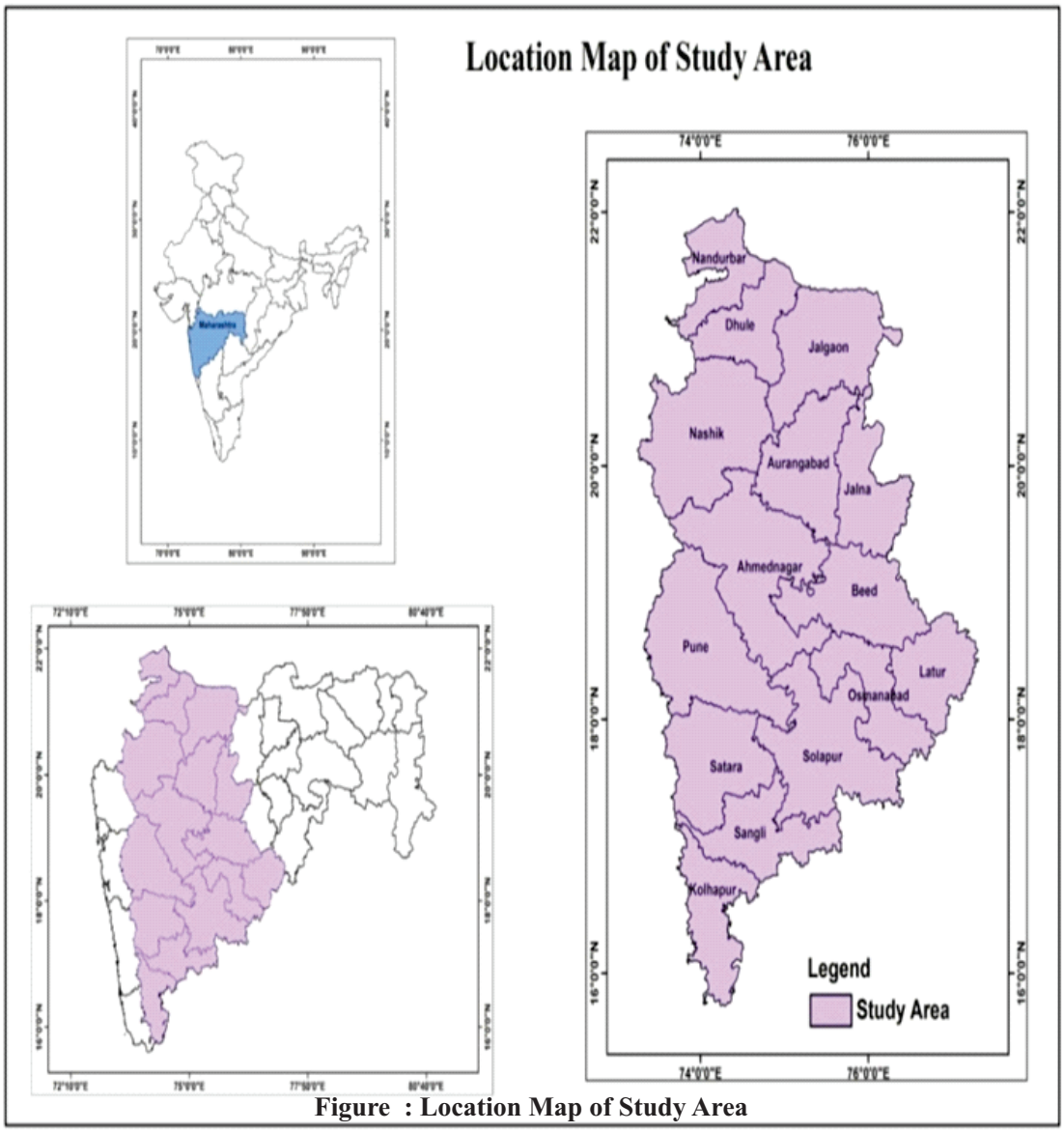


Figure : Location Map of Study Area

Prof. G. T. Trewartha modified and simplified Koppen's Classification and presented his classification in his book entitled 'An Introduction to Climate.' He explained (A, B, C, D, E and F) six climatic types out of which A and B are found in Maharashtra. B is a dry climate in which average annual rainfall is always less than (100cm). Bs is a subtype of B climate, which means a semi-arid or steppe climate, which is found in the rain shadow of the Western Ghats.

Rain shadow zone of Maharashtra state lies in the eastern part of Western Ghat, which includes three administrative divisions of Maharashtra, i.e., Pune division, Nashik division and some part of Aurangabad division. It comprises fifteen districts of Maharashtra state. The geographical location of the study area is (150 56'N to 210 45'N) latitudes and (730 30'E to 770 7'E) longitudes. Madhya Pradesh surrounds it and Gujarat states in the north, Karnataka state in the south, Western Ghat and Kokan region to the west and Vidharbha region to the east. The study region has five main rivers, i.e., Godavari, Bhima, Krishna, Tapi and Narmada.

4) Data and Methodology

4.1 Data Collection:

A) Meteorological Data: Monthly rainfall data of 120 rain gauge stations for 52 years (1965-2016) is collected from the Indian Meteorological Department, Pune (IMD) and rainfall data also collected from the Agricultural department of Maharashtra State (Maha-Agri).

B) Physical factors Data: It includes latitudes, longitudes, relief, height and drainage pattern. The data of these are collected from IMD (Pune), socio-economic abstract of districts of the study region taken from the District Census of Handbook.

4.2 Research Methodology:

The collected data of 120 stations were summed up on a meteorological monthly, seasonally and annually basis. Month- wise data were processed and tabulated for further statistical analysis as following:

A) Mean: The average monthly, seasonal and annual data is computed by using this formula.

$$Mean = \frac{EX}{N}$$

B) Standard Deviation: It is the square root of the means of the squared deviations from the arithmetic mean.

$$SD = \frac{\sqrt{\Sigma X^2}}{N} - (X^2)$$

5) Findings and Discussion:

5.1 Monthly Rainfall Distribution:

The analysis of monthly rainfall distribution has been done for the study period of 1965 to 2016. The monthly rainfall data values of all stations for the study period have been plotted and shown in the (Figures 2, 3 and 4) by maps. The maps of monthly rainfall distribution cover all stations. The darker shades indicate higher values of rainfall and lighter shades indicate lower values of rainfall. Maps show legends for monthly rainfall values in mm. January and February are mostly dry months in the study region. The eastern and some southern part of study region starts to receive less amount of rainfall in March. The rainfall of these three (January, February and March) months is less than (10mm).

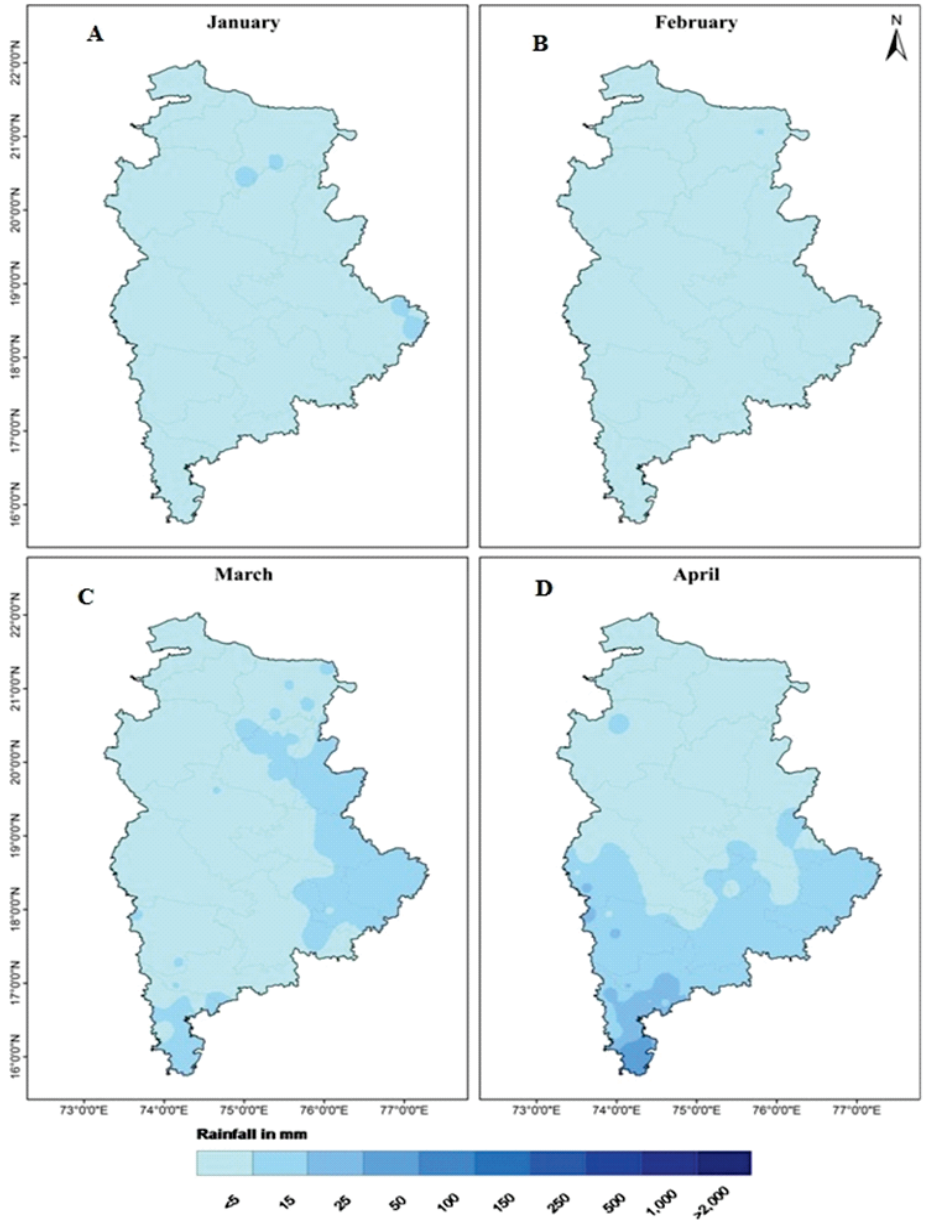


Figure:2: Monthly Rainfall Distribution Map (A-January, B-February, C-March, D-April)

The decreasing trend of rainfall from southern to northern is observed during **April and May** and these months receive less than (60 mm) rainfall. The months of **June, July and August** show a decreasing trend of rainfall from western, Northwestern, Northern to eastern and central parts of the study region.

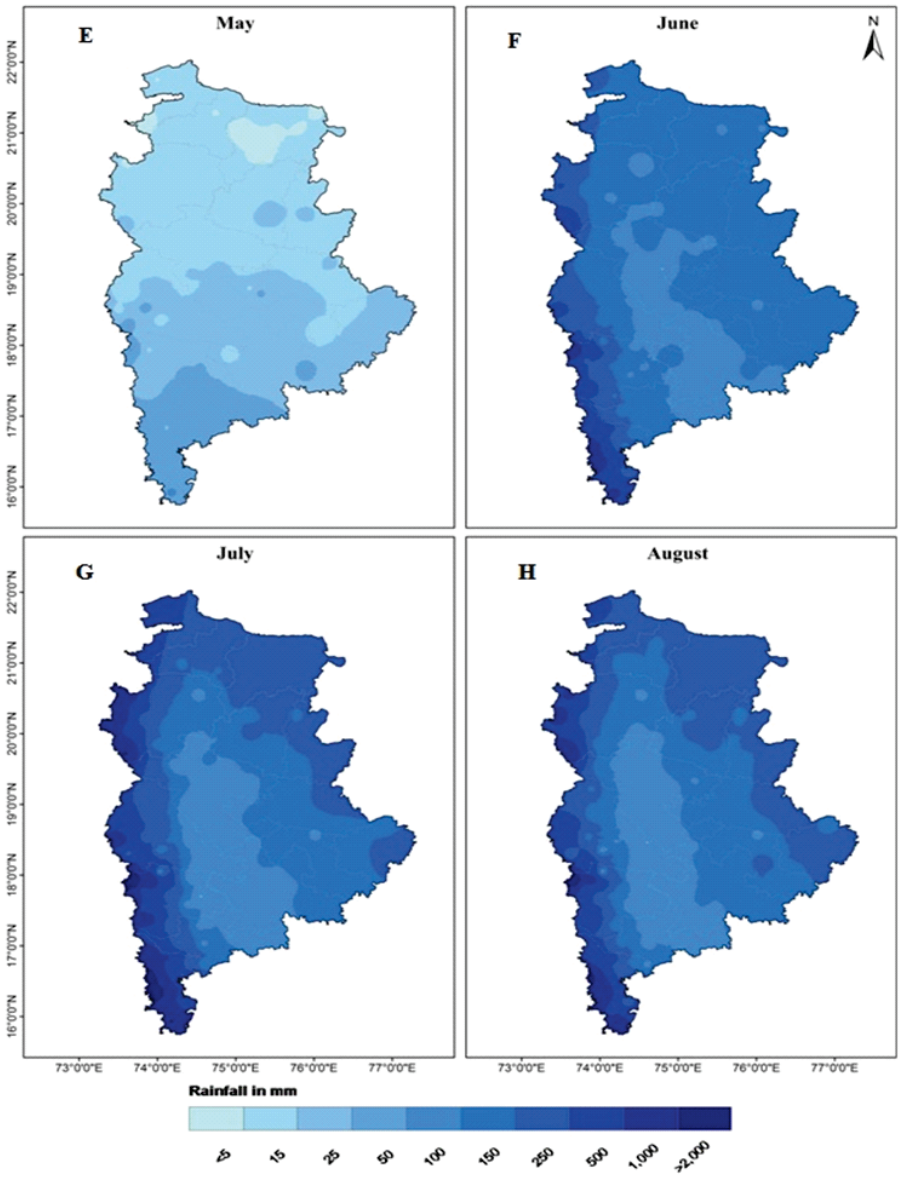
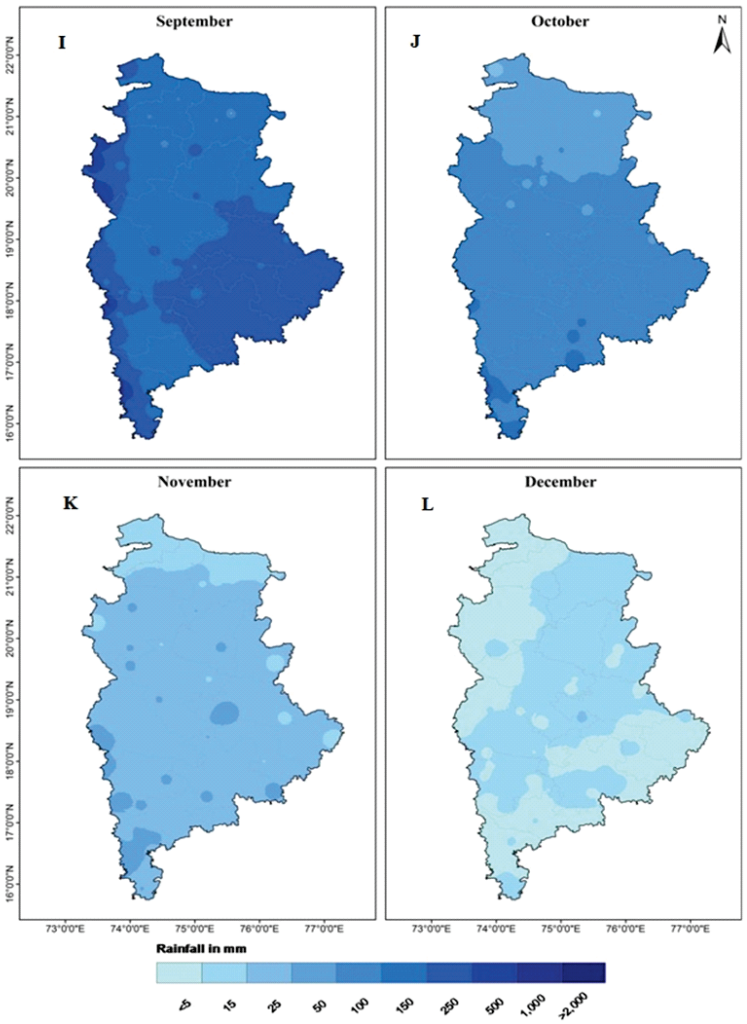


Figure 3: Monthly Rainfall Distribution Map (E-May, F- June, G-July, H-August)

The **September** month shows a decreasing trend of rainfall from both side westerns to central and also south-eastern to a central part of the study region. Again **October and November** months show mostly southern and central parts receiving medium rainfall. In the end, **December** month shows a decreasing trend from the Northeastern part to the north-western, south, south-western region. The distribution of rainfall has a considerable variation in all 12 months over different parts of the study region. It is observed that all the months receive a different amount of rainfall in five decade's average and it is recognized with the help of average monthly maps of study region that trend of monthly rainfall from January to December moves in a clockwise direction.



(Figure 4: Monthly Rainfall Distribution Map (I-September, J-October, K- November, L-December)

5.2 Seasonal Rainfall Distribution:

Figure 5 shows the seasonal rainfall distribution for the period of 1965 to 2016. Based on the percent of contribution to the annual rainfall, the rain shadow zone has four seasons of rainfall, namely, the winter season (J-F), the Pre-Monsoon season (M-M), the monsoon (J-S) and the Post-Monsoon (O-D).

A) Winter Season: The winter season is also called as the cold weather season. The winter season **Figure 5-A** shows the rainfall ranges from (3mm to 12mm). So, the winter season remains dry and contributes a low amount of rainfall to the annual rainfall. Isohyets of high rainfall values (10-12mm) are located in the eastern, north-eastern and southeastern parts of the study region and are aligned from north to south. Nevertheless, the western part of the study region hardly receives rainfall (0-3mm).

Middle of the eastern part receives moderate rainfall. Hence the map shows the decreasing trend of rainfall from eastern to the western part of the study region. **Figure 2-A** shows the month of January has contributed to 0.21 percent of rainfall in the winter season. Most of the part of the study region did

not trace rainfall this month. **Figure 2-B** shows the month of February is contributed a tiny amount of rainfall in the winter season and annual rainfall, i.e., 0.16 percent.

B) Pre-Monsoon Season: The period from March to May is known as Pre-Monsoon season and this is also called summer season, hot weather season, or hot, dry summer season. The rainfall ranges in the Pre-Monsoon season in the **Figure 5-B** are from less than 12mm to 96mm. Isohyets of high rainfall values (85-96 mm) are observed in the southern part of the study region and are aligned west to east. However, isohyets of low rainfall values (less than 12mm) e located in the northern part of the study region and it is also aligned from west to east. The middle of the region receives moderate rainfall. Hence the map shows the decreasing trend of rainfall from southern to northern part of the study region. **(Figure 2-C)** shows the March month received average rainfall from (0.17mm to 9.94mm) in the rain shadow zone of Maharashtra state. The maximum amount of rainfall is found in the eastern and southern parts. Chandgad is the rainiest station in this area. **(Figure 2-D)** shows the April, rainfall varies from (0.10mm to 34.70mm). Southern, southeastern and southwestern are mainly three high rainfall pocket areas in this month. **(Figure 3-E)** shows during the May month, the study region received (1.67mm to 51.89mm) rainfall. This month is contributed by 1.95 percent rainfall of Pre-Monsoon season. This month, the southern part of the study region received rainfall more than (40mm). The overall contribution of rainfall of this month is the highest as compared to March and May months of Pre-Monsoon season.

C) Monsoon Season: The Monsoon season in the study region starts with the onset of the southwest monsoon in June and continues till September and also called the rainy season, the southwest monsoon season, or the wet season. During the monsoon season, the rainfall ranges from (<400mm to 5200mm). **(Figure 5-C)** shows Isohyets of high rainfall values (<2000mm) is located in the western part of the study region and are aligned north to south. Nevertheless, isohyets of low rainfall values (less than 400mm) are located in the central part of the study region. The eastern part of the region receives moderate rainfall. Hence the map shows the decreasing trend of rainfall from western to eastern part of the study region. **(Figure 3-F)** shows the month of June contributed 17.90 percent rainfall of the Monsoon season. The lowest rainfall is recorded at station Ahmadnagar- OBSY (72.02mm) and the highest rainfall is recorded at Gaganbawada station (1080.53mm). **Figure 3-G** shows the 27.44 percent rainfall is the highest contribution for Monsoon season in July. The highest rainfall station of this month is Mahabaleshwar-OBSY (2052.10mm) and the lowest rainfall station is Man (53.53mm). **(Figure 3-H)** shows during August month, the study region received an average 23.06 percent rainfall of the total Monsoon season rainfall. In this month, the characteristics of average rainfall are observed as similar to June and July. The highest rainfall station for this month is similar to July. **Figure 4-I** shows the month of September contributed 17.62 percent rainfall in the Monsoon season. The maximum rainfall is received at Gaganbawada station (633.03mm) and the minimum rainfall is received at Jalgaon-OBSY station (88.20mm). The overall contribution of rainfall of the September month is the lowest as compared to June, July and August months of Monsoon season.

D) Post-Monsoon Season: The Post-Monsoon season starts with the withdrawal of southwest monsoon in October and continues till December and also known as the season of retreating monsoon or the cold season. During the Post-Monsoon season, the rainfall ranges from (<40mm to 280mm). **(Figure 5-D)** shows the Isohyets of high rainfall values (<1200mm) is located in the southern part of the study region and are aligned west to east. However, isohyets of low rainfall values (less than 40mm) are located in the northern part of the study region and it is also aligned west to east. The central part of the region receives moderate rainfall. Hence the map shows the decreasing trend of rainfall from southern to northern part of the study region. **(Figure 4-J)** shows during October, the rain shadow zone received 7.61 percent rainfall of the Post-Monsoon season. The spatial distribution of rainfall of this month looks like a spatial pattern of Post-Monsoon season. **(Figure 4-K)** shows in November, rainfall is contributing 2.34 percent in the Post-Monsoon season. Gaganbawada station is noted as the highest rainfall receiving station for both the nths (October and November) of the season. **(Figure 4-L)**

shows the month of December has contributed 0.61 percent rainfall in the Post-Monsoon season. The overall contribution of rainfall of this month is the lowest as compared to October and November months of the Cool season.

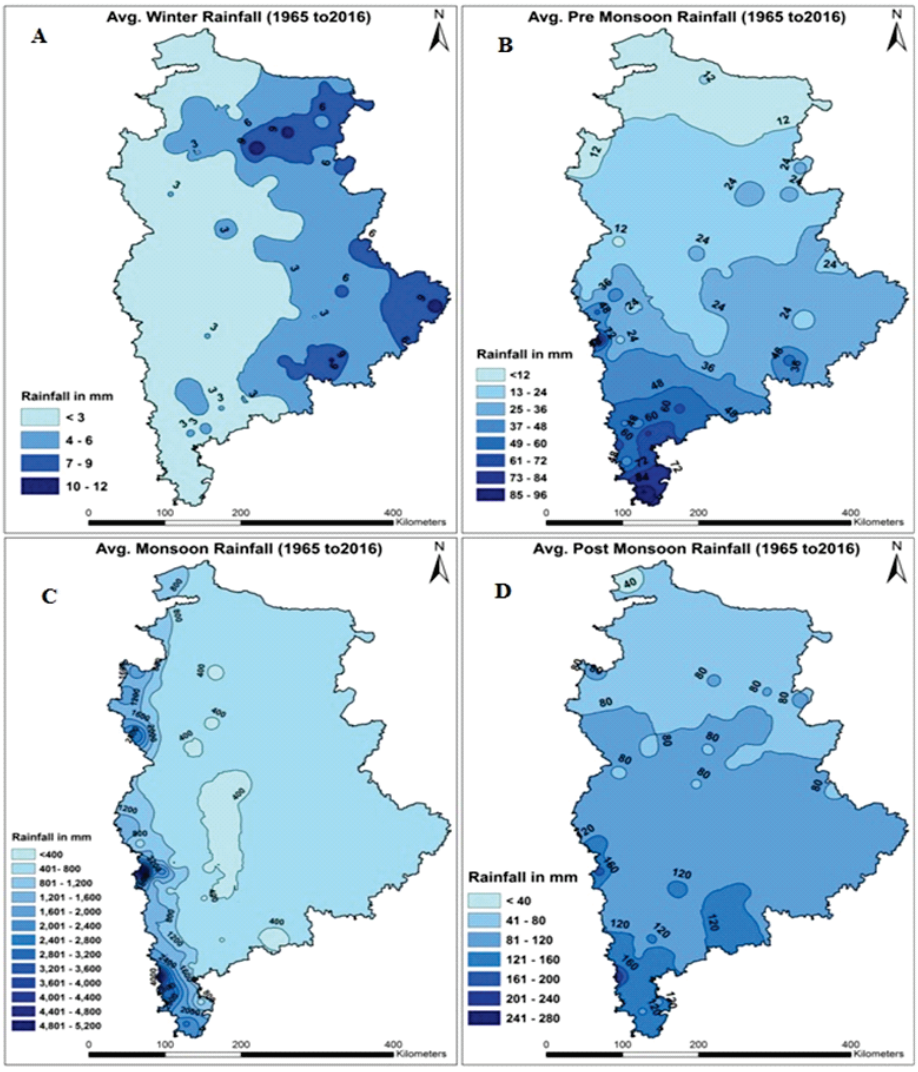


Figure 5: Seasonal Rainfall Distribution Map (A-Winter, B-Pre-Monsoon, C-Monsoon, D-Post Monsoon)

5.3 Annual Rainfall Distribution:

The average annual rainfall for the period of (1965-2016) over the study region varies from (<500mm to > 5500mm). The total average annual rainfall of five decades of the study region is (873.65mm). The distribution of average annual rainfall **(Map 6)** shows the increasing trend of rainfall from eastern to the western part of the rain shadow zone.

A) Areas Receiving Very Heavy Rainfall: Areas receiving an annual rainfall of (2000mm) and above are known as areas of the heavy rainfall. These include six stations Gaganbawada (5382.84mm), Mahabaleshwar-OBSY (5342.25mm), Radhanagari (3186.19mm), Igatpuri (2879.62mm), Chandgad (2708.69mm) and Velhe (2306.50mm). All these stations are located inthe western part of the study

region firmly attached to Western Ghat. Gaganbawada and Mahabaleshwar are the highest rainfall stations that receive average annual rainfall above (5000mm) in the study region and similar results were reported for Gaganbawada from 2001 to 2013 by Mangalekar (2015) and for Mahabaleshwar from 1998 to 2016 by Deshmukh and Matkar (2017).

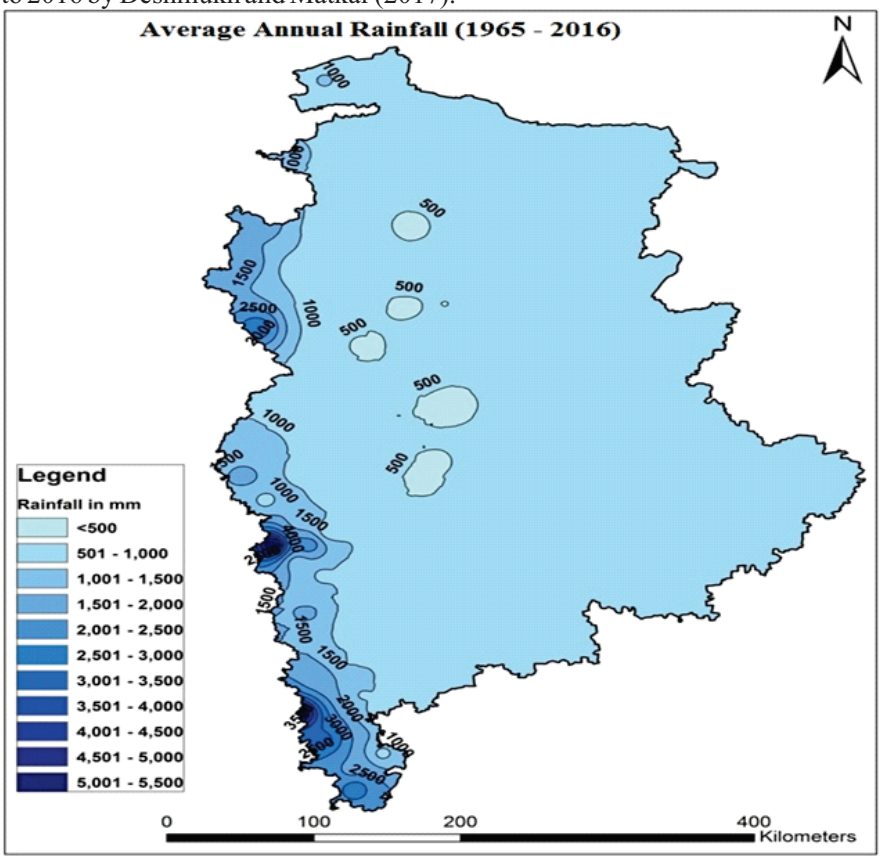


Figure 6: Annual Rainfall Distribution Map (1965-2016)

B) Areas Receiving High Rainfall: It is found that the range of high rainfall average (1500mm to 2000mm) includes six rainfall stations. Ajara (1895.19mm), Peth (1887.29mm), Surgana (1849.97mm), Shahuwadi (1769.34mm), Mulshi (1636.61mm) and Patan (1536.55mm) and these stations are also totally observed over the western part of the study region.

C)Areas Receiving Moderate Rainfall: Moderate rainfall receiving areas have average rainfall range between (1000mm to 1500mm) and also include six rainfall stations. These stations are Panhala (1499.51mm), Wadgaon (1269.75mm), Jawali (1182.14mm), Bhor (1138.40mm), Navapur (1085.16 mm) and Akkalkuwa (1013.06 mm).

E) Areas Receiving Low Rainfall: The Central and eastern part has an average rainfall range (500mm to 1000mm) where low rainfall is observed. The low rainfall stations are more in numbers, i.e., (95mm). It means low rainfall covers many areas over the study region.

F) Areas Receiving Scanty Rainfall: The range of scanty rainfall average is less than (500mm) which is observed over the seven stations (Sangamner (422.11mm), Malegaon-OBSY (429.52mm), Ahamadnagar-OBSY (441.54mm), Kopergaon (457.53mm), Daund (484.28mm), Vaijapur (498.11mm) and Parner (499.82mm) of the central part of the study region.

6) Limitations of the study:

Weather data for an extended period is not available freely from Indian Meteorological Department. Out of 120 rain gauge stations complete 52 years monthly and annually rainfall data were available only for 16 stations and 104 stations missed some year's data. Due to this data problem, it is tough to conclude the expected result. Cleaning, sorting, analyzing the data took a considerable time, but the research work has a time limit that should be followed. Also, enough literature is not available for a rain shadow zone of India as well as Maharashtra.

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