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The Seasonal Characteristics and Variability of Rainfall in the Ahmednagar District of Maharashtra, India: A Statistical Analysis

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Abstract - Water is scarce in many sections of the nation outside of the monsoon season because of the significant concentration of rainfall during those months. Since agriculture in India is so dependent on monsoon rains, any change in the amount of rain that falls during the season may have far-reaching social and economic consequences. The Indian state of Maharashtra includes the Ahmednagar District, which includes the Ahmednagar Tahsil. All of the precipitation information used in this study comes from the Ahmednagar district's statistics department website (MK). There are fourteen tahsil in the Ahmednagar District for Shrirampur, Parner, Shrigonda, Karjat, Jamkhed, and Nagar tahsil of Ahmednagar District exhibit declining tendencies (Negative), whereas Akole, Sangamner, Kopergaon, Rahuri, Newasa, Rahata, Shevgaon, and Pathardi tahsil show rising tendencies.

Keywords - drought Prone Area, Watershed Management, Rainfall Characteristics, Rainfall Distribution and Rainfall Variability

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INTRODUCTION

The timely availability of an acceptable quantity of water and a favourable environment are vital to India's agriculture and allied industries, food security, and energy security. Long-term rainfall patterns may be affected by global climate change, which might reduce water supply and raise the risk of droughts and floods. Because it accounts for over 80% of annual precipitation, the south-west monsoon is particularly important for maintaining adequate supplies of potable water and water for farming. Since most of the year's precipitation falls during the monsoon season (June–September), many regions of the nation have water shortages in the intervening months. Large storage reservoirs are needed to redistribute the natural flow so that it meets the needs of certain areas because of the uneven distribution of rainfall and the mismatch between water supply and demand. The lack of enough precipitation throughout the growing season hampers plant development. Plants get drowned by excessive rain during their early stages of development.

Since agriculture in India is so dependent on monsoon rains, any change in the amount of rain that falls during the season may have far-reaching social and economic consequences. In order to properly prepare for and respond to catastrophic occurrences, it is crucial to examine the pattern of rainfall over time. There is no totally perfect mathematical definition of trend, but a common working definition is "long-term change in the mean level." Forecasting, however, benefits from trend analysis. Statistic analysis is the backbone of every reliable scientific prediction. Longitudinal changes in rainfall patterns across several census tracts were analysed using a trend analysis method. The national economy and hydrological infrastructure rely heavily on accurate predictions of future rainfall. For a time, series to be considered trending, it must show either increasing or decreasing values across several time intervals.

The Indian state of Maharashtra includes the Ahmednagar District, which includes the Ahmednagar Tahsil. There is an average of 560.69 mm of precipitation every year, with average lows of 19.2 degrees Celsius and average highs of 32.9 degrees Celsius. After the monsoon, there comes a second heat wave. Precipitation in Ahmednagar typically averages 423.26 mm over the monsoon season, but may range from 77.9 mm to 690 mm. The design of irrigation and drainage systems, as well as the overall programme of command area development, relies heavily on an accurate assessment of historical rainfall patterns in each given location. An accurate estimation of rainfall depth and its return duration from available historical data is necessary for many applications in water resources engineering.

LITERATURE REVIEW

Dr. Namdev V et.al (2019) The lack of water is a major problem in both dry and semiarid areas. The article examines seasonal and annual rainfall and wet days statistics for the semi-arid area of Sangli District in the Yerla River basin, Maharashtra, from 1980 to 2012. The research location is located in the rain shadow zone of the basaltic Deccan Traps region and gets an average yearly rainfall of 632.22 mm. Drought is a recurring problem because early rains are insufficient and late rains are unpredictable. With the help of Microsoft Excel, we analysed the monthly and yearly rainfall and rainy days data of the Vita and Tasgaon stations from the India Meteorological Department. There is a direct and positive correlation between the yearly rainfall and the number of wet days recorded at each weather station. The rainy season is characterised by wet and dry periods that occur at varying intervals.

Virendra N. Barai et.al (2021) Rainfall is one of the most important climatic variables, thus it's important to examine its long-term behaviour throughout space using various time series, such as yearly, monthly, and weekly. The ability to track changes in precipitation over time helps farmers prepare for the challenges posed by climate change. A number of studies have been conducted to identify the pattern of rainfall across different time periods for different places; this information may be utilised to improve agricultural planning, water supply management, etc. In light of this, an examination of rainfall trends in the Ahmednagar district of Maharashtra was conducted and written up here. Thirteen tahsils in the Ahmednagar district were chosen for the trend study. Using the daily rainfall data from all stations over a 33-year period (1980-2012), we can examine the variability in rainfall. Methods such as the Mann-Kendall (MK) Test, Sen's slope technique, moving average, and least squares analysis were utilised.

Dr. Vidya C. Kachkure et.al (2021) According to NIOS Geography (not cited in abstract), "Rain Shadow Region" refers to the dry area that is on the mountain's windward side. In order to effectively manage water resources, agriculture, economic activities of the people, and the unique flora and fauna populating the studied area, knowledge of rainfall and its distribution is essential. The continuous lack of water in rain shadow regions makes them very vulnerable to meteorological and agricultural droughts. This research uses mean and standard deviation techniques to examine monthly, seasonal, and yearly rainfall data from 120 rain gauge stations in the rain shadow zone of the Western Ghats in the Indian state of Maharashtra from 1965 to 2016. Arc-GIS was used for making geographical maps, whereas Excel was utilised to calculate rainfall amounts.

Dattatray Ghungarde et.al (2020) The growth of any given area is in large part determined by its climate. The climatic state of any given location is determined mostly by its average rainfall and average temperature. The central region of the state of Maharashtra, including the district of Ahmednagar, is particularly vulnerable to drought. According to the Intergovernmental Panel on Climate Change (IPCC, [5]), the changing pattern of rainfall would be a major factor determining economic development in the areas, particularly in countries like India, where the livelihood of 70 percent of the population relies on agriculture. However, due to the unpredictable nature of the monsoon, agriculture relies on it.

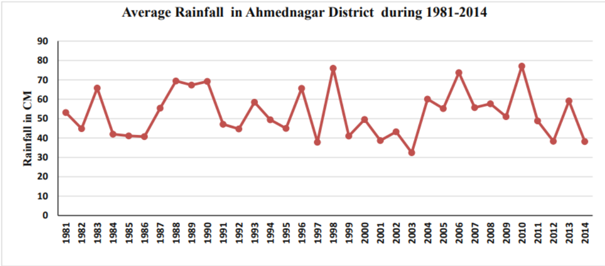
METHODOLOGY

There is secondary data use in this study, which benefits the Ahmednagar Statistical Center. Some non-parametric Mann-Kendall (MK) tests were used to evaluate the data, and the results were shown in tables and maps. The SPSS programme was used for the analysis, and the Arc GIS10.3 edition GIS programme was utilized for the mapping. Using the difference in index values between 1981, 1992, 2003, and 2014, she has created three sets of maps for this study: one for areas with precipitation over 650 mm; one for areas with precipitation between 575 and 650 mm; and one for areas with precipitation below 575 mm. In addition, both positive and negative maps covering the years 1981-2014 have been created. Also, a line graph depicting the average rainfall from 1981–2014 is shown.

DATA ANALYSIS

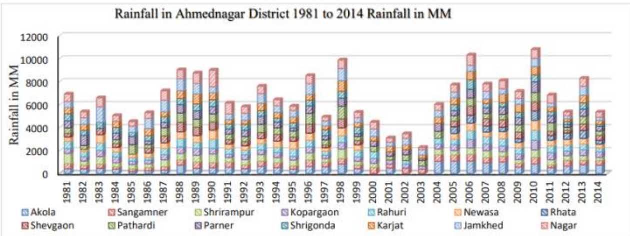
The district of Ahmednagar in the Indian state of Maharashtra is one of the most vulnerable to drought. Because of this, agricultural progress within the economy is a challenge in the Ahmednagra district. Northern and southern Ahmednagar are the two main sections of the district. Despite canal irrigation facilities in the district, the rural areas are experiencing a shortage of water, and the greatest number of villages have been affected by tankering. A lack of water prevents agricultural development in the state's drought-prone region. The challenge of slowing agricultural expansion is affecting even irrigated regions in the research region. Several of the southern Ahmednagar villages have been experiencing water shortages. The overexploitation of water for agricultural and other uses has caused this serious environmental problem.

Average Rainfall:



Graph no 01: Average Rainfall (Rainfall in CM)

Rainfall amounts for the whole tehsil of the research region are shown in Graph No. 2, which spans the years 1981 through 2014. Shrigonda, Shevgaon, Karjat, Jamkhed, Pathardi and Nagar have the least precipitation (less than 450 mm), Rahata, Rahuri, Shrirampur, Kopergaon,,Parner have moderate precipitation (450-550 mm), and akole tehsil has the most precipitation (more than 650 mm). The most essential aspect in the total rainfall over a period of 36 years is that Karjat, Jamkhed, Shrigonda, Shevgaon, Pathardi and Nevasa tehsils is drought prone region is the exporter with the lowest rainfall. Find here the rest of the data from Graph #2.



Graph no 02: Average Rainfall in Tehsil wise

Rainfall Distribution:

The distribution of precipitation during the 1981 period is shown on map no. 2, which divides the country into three rainfall zones (or tehsils) with mostly high (above 650mm), moderate (575-650mm), and low (less than 575mm) precipitation, respectively. Shrirampur tehsil received 880 mm of rain during this time, followed by Rahuri (639 mm), Parner (622 mm), Shrigonda (614 mm), and Nagar (610 mm) (639mm). Akola (404mm), Sangamner (459mm), Kopargaon (420mm), Newasa (366mm), Shevgaon (314mm), Pathardi (483mm), Karjat (542mm), and Jamkhed (542.1mm) are the tehsils with the lowest annual rainfall.

Table No 1: Rainfall distribution in 2016

Index	Index value	Number of Tehsils	Name of the Tehsil
High Rainfall	Above 650 mm.	01	Shrirampur
Moderate Rainfall	575 -650 mm.	04	Rahuri, Parner, Shrigonda, Nagar.
Low Rainfall	Below 575 mm.	08	Akola,Sangamner,Kopargaon,Newasa Rahata ,Shevgaon, Pathardi ,Karjat,Jamkhed

Only one tehsil, Jamkhed, in the moderate rainfall zone has seen above-average precipitation this year, despite the fact that the 2016 rainfall distribution is depicted on map no. 3. Twelve tehsils, including Shrirampur (456 mm), Rahuri (407 mm), Parner (551), Shrigonda (522 mm), and Nagar (52 mm), are in the low rainfall zone this year. Karjat (435 mm), Pathardi (435 mm), Shevgaon (369 mm), Akola (405 mm), Sangamner (456 mm), Kopargaon (418 mm), Newasa (380 mm), and Sangamner (456 mm)

Table No 2: Rainfall distribution in 2017

Index	Index value	Number of Tehsils	Name of the Tehsil
High Rainfall	Above 650 mm.	00	Nil
Moderate Rainfall	575 -650 mm.	01	Jamkhed
Low Rainfall	Below 575 mm.	12	Shrirampur Rahuri, Parner, Shrigonda, Nagar. Akola,Sangamner,Kopargaon,Newasa ,Shevgaon , Pathardi ,Karjat.

According to 2017 rainfall distribution chart #4, no tehsil in the high and medium categories had precipitation at such levels in 2003. If this is the case, then the year in question was marked by a severe drought. 14 tehsils, including Jamkhed (460mm), Shrirampur (313mm), Rahuri (299mm), Parner (190mm), Shrigonda (87mm), Nagar (199), Akola (489 mm), Sangamner (380 mm), Kopargaon (280 mm), Newasa (219 mm), Shevgaon (320 mm), Pathardi (476 mm), Karjat (281 mm), and Rahat

Table No 3: Rainfall distribution in 2018

Index	Index value	Number of Tehsils	Name of the Tehsil
High Rainfall	Above 650 mm.	00	Nil
Moderate Rainfall	575 -650 mm.	00	Nil
Low Rainfall	Below 575 mm.	14	Jamkhed, Shrirampur Rahuri, Parner, Shrigonda, Nagar, Akola ,Sangamner ,Kopargaon,Newasa ,Shevgaon , Pathardi ,Karjat, Rahata.

The 20148precipitation pattern is shown on map. This year, Akole (733 mm) is the only tehsil to get heavy rainfall, while there are no tehsils that fall into the moderate rainfall category. Jamkhed (268 mm), Shrirampur (273 mm), Rahuri (322 mm), Parner (414 mm), Shrigonda (176 mm), Nagar (465 mm),,Sangamner (392 mm),Kopargaon (491 mm), Newasa (337 mm), Shevgaon (429 mm), Pathardi (379 mm), Karjat (344 mm), and Rahata (36 mm)

Table No 4: Rainfall distribution in 2019

Index	Index value	Number of Tehsils	Name of the Tehsil
High Rainfall	Above 650 mm.	01	Akole
Moderate Rainfall	575 -650 mm.	Nil	Nil
Low Rainfall	Below 575 mm.	13	Jamkhed, Shrirampur Rahuri, Parner, Shrigonda, Nagar,
			,Sangamner,Kopargaon,Newasa
			Shevgaon, Pathardi, Karjat, Rahata.

There was a noticeable shift in precipitation over the course of 33 years, as seen by Map No. 6. Both good and negative shifts from 181 to 2019 are highlighted. There have been significant improvements in Akole (329 mm), Kopargaon (71 mm), and Shevgaon during the last 33 years (115mm). The remaining ten tehsils all saw negative precipitation during this time period: Jamkhed (259 mm), Shrirampur (607 mm), Rahuri (317 mm), Parner (208 mm), Shrigonda (438 mm), Nagar (174 mm), Sangamner (67 mm), Newasa (29 mm), Pathardi (104 mm), Karjat (198 mm), and Newasa (29 mm).

Table No 5: Change of Rainfall (2016 to 2019)

Index	Number of Tehsil	Name of the Tehsil
Positive change	03	**Akole,** Kopargaon,Shevgaon
Negative change	10	Jamkhed, Shrirampur Rahuri, Parner, Shrigonda, Nagar, ,Sangamner ,Newasa ,Shevgaon , Pathardi ,Karjat.

From the Indian Meteorological Department (IMD), Pune, we collected annual rainfall data from 14 raingauge stations in the Ahmednagar district between 2016 to 2019. It is common practise to use the Mann-Kendall test (Mann, 1945, and Kendall, 1975) to determine the statistical significance of a positive or negative trend in time series data.

Mann–Kendall (M–K) test statistic is defined as

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign\ (T_j - T_i)$$

$$Sign\ (T_j - T_i) = \begin{cases} 1\ if\ T_j - T_i > 0 \\ 0\ if\ T_j - T_i = 0 \\ -1\ if\ T_j - T_i < 0 \end{cases}$$

The magnitude of the trends was also calculated using Sen's method. Time-series analysis is performed on the data values. The lack of a trend (the "null hypothesis H0") is put up against the presence of a trend (the "alternative hypothesis H1") in this test.

at Rahata, 186 mm, and in Jamkhed, 693 mm. The difference between Sangamner and Rahata may be seen in the standard deviation, which ranges from 111.34 mm to 257.51 mm. Individually for each of Ahmednagar district's 14 tahsil, we estimated the 31-year rain fall trend using the non-parametric Mann-Kendall test. Slopes of 0.45, 0.267, -0.086, 0.194, 0.148, 0.116, 0.626, 0.198, 0.069, -0.245, -0.056, -0.028, -0.039, and -0.135 were seen when Sen used the Mann-Test Kendall's to define the trend. Shrirampur, Parner, Shrigonda, Karjat, Jamkhed, and Nagar showed a declining tendency, whereas Akole, Sangamner, Kopergaon, Rahuri, Newasa, Rahata, Shevgaon, and Pathardi showed an increasing one (Negative).

Table 6: Rainfall Trend Analysis of Ahmednagar district during 2016 to 2019

Sr. No	Tehsils	Mean	SD	Mann-Kendall Trend test	P Value	Sen's slope	Trends at 5 % significance Level
1	Akole	574.32	249.48	0.45	1.00	14.400	Positive Trend
2	Sangamner	412.181	111.346	0.267	0.982	5.029	Positive Trend
3	Shrirampur	489.416	153.091	-0.086	0.254	-1.947	Negative Trend
4	Kopergaon	467.394	134.437	0.194	0.935	4.385	Positive Trend
5	Rahuri	531.355	154.841	0.148	0.882	3.900	Positive Trend
6	Newasa	484.526	160.633	0.116	0.816	3.389	Positive Trend
7	Rahata	186.903	257.513	0.626	1.00	16.048	Positive Trend
8	Shevgaon	520.697	181.123	0.198	0.939	5.889	Positive Trend
9	Pathardi	600.745	202.899	0.069	0.701	1.667	Positive Trend
10	Parner	526.674	174.643	-0.245	0.027	-6.667	Negative Trend
11	Shrigonda	482.684	121.093	-0.056	0.335	-0.571	Negative Trend
12	Karjat	554.097	162.127	-0.028	0.42	-1.500	Negative Trend
13	Jamkhed	693.339	226.762	-0.039	0.386	-1.667	Negative Trend
14	Nagar	613.294	237.080	-0.135	0.148	-4.960	Negative Trend

(Source: Computed by Researcher)

CONCLUSION

The timely availability of an acceptable quantity of water and a favourable environment are vital to India's agriculture and allied industries, food security, and energy security. Economic growth and hydrological infrastructure planning in the nation depend critically on the rain pattern. In order to effectively plan for, and develop, water resources at the local or regional level, accurate and complete hydrological data about the area in question is required. In this study, we found that the Mann-Kendall Test (MK) is useful for detecting trends in data from the tahsils of Akole, Sangamner, Kopergaon, Rahuri, Newasa, Rahata, Shevgaon, and Pathardi. Akole tehsil receives more rain than usual since its topography is one of the most significant elements influencing the dispersion of precipitation. All tehsils in the Ahmednagar district have become very drought-prone, with the exception of Akole tehsil.

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