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Change in Climate and a Study of Its Impact on the Temperature, Precipitation and Evapotranspiration Trends in Karimnagar District of Telangana State

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Abstract: ***A lot of research is being carried out on the climate trends of particular region. Regional changes in climatic parameters are studied in comparison with global climate change which will in turn assist in providing the basic support for environmental system adjustments. It is crucial to understand the impact of climate change has on crop production because crops are highly sensitive to climate variations. Agro-ecological conditions also keep shifting due to alterations in hydrological characteristics like the setting in, during and intensity of the yearly monsoon. In this study an attempt is made to discover the temporal variations of some climate indicators like temperature, and precipitation, evapotranspiration. The three temporal analysis scales- annual, seasonal and monthly are taken into consideration as part of the study. Each temporal scales exhibited different characteristics for each climatic parameter. The monthly period that was analyzed displayed a more vivid trend dynamics for temperature, precipitation and evapotranspiration.***

Keywords: climate change, crop production, monsoon variability, regional climate analysis, temporal climate trends

1. Introduction

Most of the research on climatic variation is focused on the analysis of crucial climate parameters variability that has its impact on bio physical process like rainfall, temperature and evapotranspiration. For the last three decades, it has been observed that the global average atmospheric temperature is increasing at a high pace. The global temperature increased by 0.74°c approximately in between the years 1906 and 2005 (IPCC 2007). Evaporation which is largely influenced by temperature plays a significant role in energy flows between the atmospheric and terrestrial systems. It is now universally accepted that human induced greenhouse gas emissions are responsible for global surface temperature. Climate change concerns in India include the rising temperature, projected pattern of precipitation its intensity frequency and enhanced incidences and intensity of extreme events such as cyclones, flash heavy rains, droughts and frequent floods. With a rapidly expanding economy many changes are taking place in India today. Land use, cropping and water use patterns are changing, partly as response to changing investment scenarios and economic growth.

1.1 Background of the Study

Climate change is a global phenomenon with profound implications for regional weather patterns and natural resources. The Karimnagar district in Telangana, primarily agrarian, is particularly sensitive to variations in climate. Changes in temperature, rainfall patterns, and evapotranspiration rates can directly impact agriculture, water availability, and livelihoods.

1.2 Need for the Study

Despite global and national efforts to monitor climate change, localized studies are vital for regional planning and adaptation. Karimnagar, experiencing irregular monsoons and rising temperatures, requires a detailed assessment of climatic variables over time.

Various studies about climate changes using Global Climate Models (GCMs) and Regional Climate Models (RCMs) over India during the 21st century indicate changing patterns of Rainfall and an increase in temperature. Utility of precipitation primarily depends upon its spatial as well as temporal distribution. Uniform precipitation over a larger area is more useful than its occurrence over a smaller region. Also, precipitation occurring over a larger time period would be more effectively utilized rather than when it occurs within a short of time. Therefore, projected span changes in precipitation patterns over the Indian subcontinent in near future would result in deterioration of water resources. First, decrease in winter precipitation would reduce the total seasonal precipitation being received during December - February, implying greater water stress during the lean monsoon period. Secondly, intense rain occurring over fewer days besides causing increased frequency of floods during the monsoon season, will also mean that much of the monsoon rain would be lost as direct run off resulting in reduced Ground water recharging potential.

1.3 Objectives of the Study

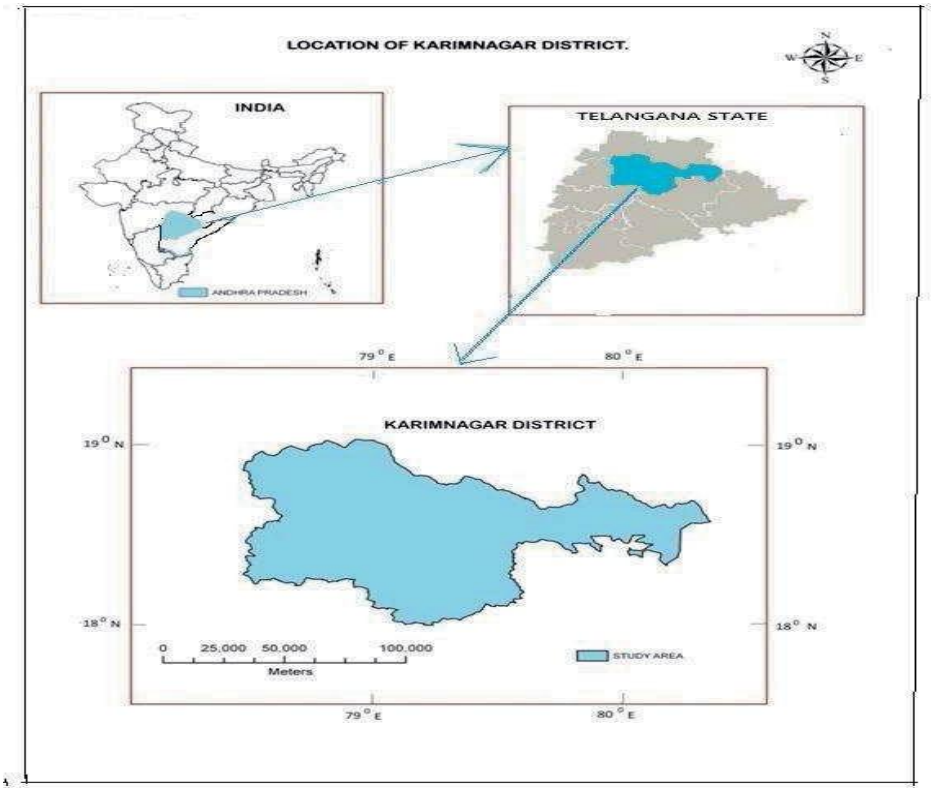
- To analyze long-term trends in temperature, precipitation, and evapotranspiration in Karimnagar district.
- To examine the relationship between these climate variables.
- To assess the implications of climate change on agriculture and water resources.
- To propose adaptive strategies for sustainable development.

2. Materials and Methods

Study Area

The Karimnagar district lies between 17^0 50” and 19^0 05” Northern latitudes and 78'29” and 80'22” Eastern longitudes. It covers an area of 11,823 sq.km and administratively the district is divided into 57 mandals. Karimnagar district is

bounded by Warangal and Medak districts in the South, Nizamabad district in the West, Chhattisgarh state in the north-east and Adilabad district in the North directions. Karimnagar, the administrative headquarters of the Karimnagar District, is situated 160 km north east of Hyderabad in Telangana. Karimnagar has a population of 38,11,738 as per 2011 census. The district has a population density of 322 inhabitants per square kilometer. Maximum Tempareture 44^0c and minimum Temperature 22^0C. The history of the Karimnagar district starts from the Old Stone Age i.e. from 1,48,000 BC. It is evident from the tools, culture and other materials found at different places in Karimnagar. The excavations at Peddabonkur, Dholikatta and Kotilingalu are evidences for history. From these evidences it is concluded that Karimnagar is ruled by Shathavahanas. After Shathavahanas, Mourya Kings, Asafzalu Kings ruled over Karimnagar. The buildings, constructions made by these kings are today remarkable evidences of the history.



Karimnagar District map

3. Methodology

To understand the changes in the temperature and rainfall patterns, the secondary data was collected from Indian Meteorological Department (IMD), mandal revenue officers and directorate of economics and statistics for a period of 40 years (1979- 2018). The data was analyzed using IBM SPSS. Based on monthly temperatures potential-evapotranspiration (PET) was computed using Thornthwaite equation (1948) method. To identify the temporal trends of the three climatic parameters, the Mann-Kendal method was used.

Effects of Climate Change on Agriculture Sector

Key Issues-

- Temperature fluctuations
- Weather changes.
- Changes in precipitation (Rainfall).
- Evapotranspiration
- Higher atmospheric CO_2 concentrations which lead to emission of greenhouse gases
- Effects on Biodiversity

4. Result and Discussion

Deviation in rainfall has always been the area of interest for every climate analyst and agricultural researcher. Especially the annual average temperature which is derived from the minimum and maximum temperature throughout the year and the average precipitation during the monsoon season as well as the individual months which the monsoon seasons consist of are the key factors that reveal the actual climatic scenario of any study region. This helps in understanding the reason of changes in agricultural production-productivity and patterns-practices of agriculture for any specific agroclimatic region. Here the study analyses various
degrees of the climate variability and its suitability for agricultural practices for both the Study Areas with the help of Temperature and Precipitation distribution over a period of 40 years from 1979 to 2018 and the Normal are also derived from the assumed study duration instead of the existing ones.

Precipitation and Temperature Deviation in Karimnagar:
Fluctuation in Temperature is evident as time passes. Over 40 years of study elucidates a detail about the fluctuation of Temperature in the District from Monthly to Annual or Decadal and are measured on a scale of Deviation from the Normal. The limits of the positive and negative deviations of Maximum, Minimum and Mean Temperature for each month for over 40 years are given in the table (Table 1). The table 1 describes that, during the colder months (coloured as green),

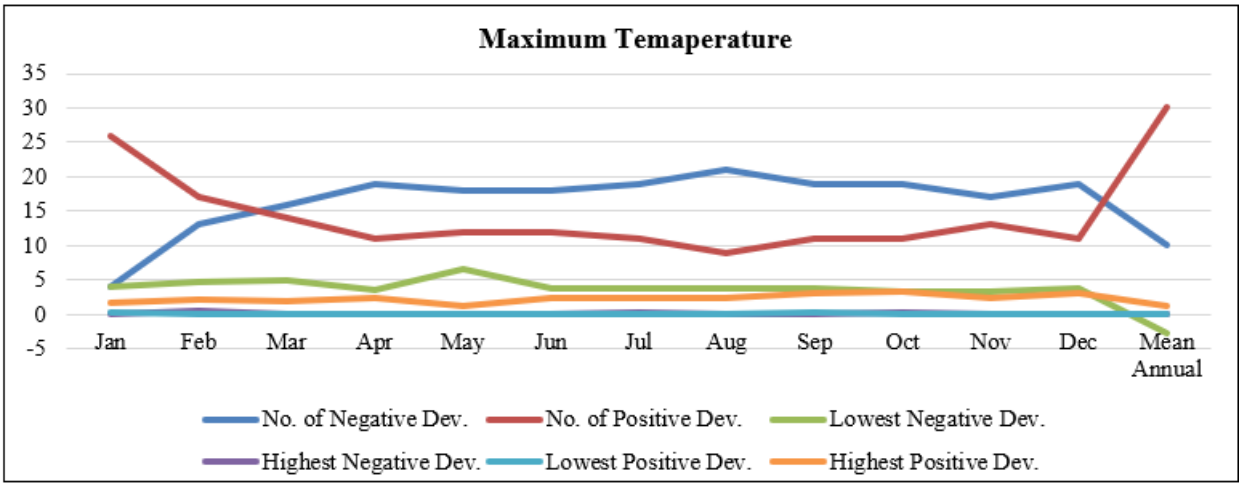
the Maximum ,Temperature positively deviated by 0.06°C to 2.17°C for 26 to 27 years and the Minimum Temperature increased by 0.02°C to 5.63°Cin 17 to 20 winters out of 40.As it is seen the Maximum Temperature declined by0.01°C to 4.98°C for 13 to 17 years, also the similar is observed in case of the Minimum Temperature. In 18 to 20 winters, the Minimum Temperature is recorded to be decreasing by 0.02°C to 3.77°C from the Normal. Similarly, in 19 to 23 winter months the Mean Temperature showed 0.01°C to 1.82°C positive deviation whereas 17 to 18 winter months showed 0.07°C to 1.98°C negative Deviation. This indicates that most of the winters were not much colder as expected but certain winters remained colder than the Normal.

Number of Occurrences & Degree of Positive & Negative Deviation of Max., Min., and Mean Temperature in Karimnagar (1979 to 2018)

Maximum Temperature

Table 1

Month	No. of Negative Dev.	No. of Positive Dev.	Lowest Negative Dev.	Highest Negative Dev.	Lowest Positive Dev.	Highest Positive Dev.
Jan	4	26	4	0.08	0.2	1.8
Feb	13	17	4.7	0.42	0	2.1
Mar	16	14	4.9	0.01	0	2
Apr	19	11	3.5	0.05	0.1	2.3
May	18	12	6.7	0.01	0.04	1.3
Jun	18	12	3.8	0.06	0.1	2.3
Jul	19	11	3.8	0.24	0	2.5
Aug	21	9	3.8	0.01	0.1	2.3
Sep	19	11	3.8	0.12	0.2	3.2
Oct	19	11	3.4	0.2	0.1	3.4
Nov	17	13	3.4	0	0.1	2.4
Dec	19	11	3.9	0.02	0.1	3.2
Mean Annual	10	30	-2.84	-0.02	0.03	1.16

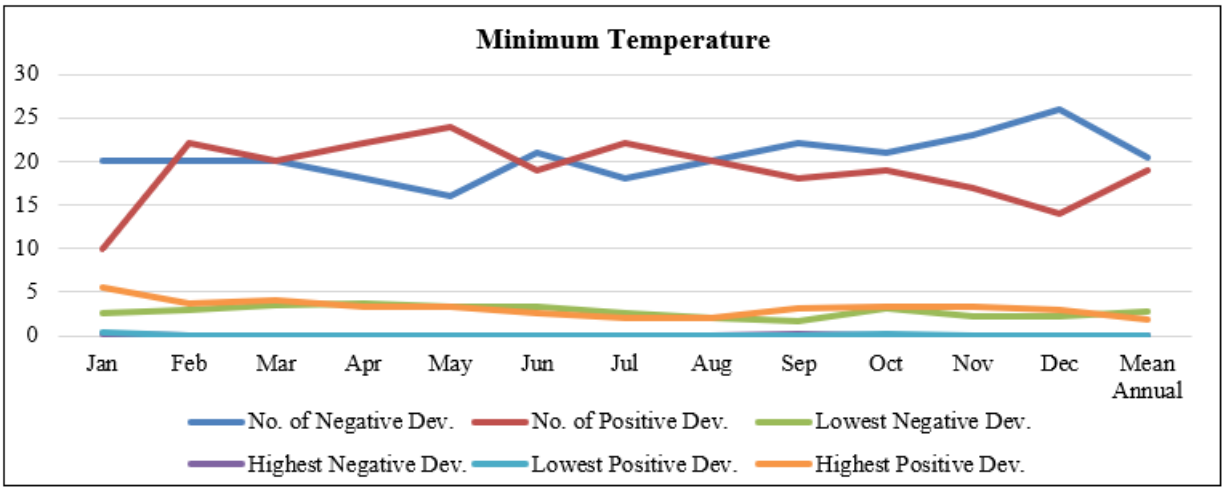


Graph 1

Minimum Temperature

Table 2

Month	No. of Negative Dev.	No. of Positive Dev.	Lowest Negative Dev.	Highest Negative Dev.	Lowest Positive Dev.	Highest Positive Dev.
Jan	20	10	2.5	0.1	0.3	5.6
Feb	20	22	3	0	0	3.6
Mar	20	20	3.5	0	0	4
Apr	18	22	3.7	0	0	3.4
May	16	24	3.4	0	0	3.4
Jun	21	19	3.4	0	0	2.6
Jul	18	22	2.6	0	0	2.1
Aug	20	20	2.1	0	0	2.1
Sep	22	18	1.7	0.1	0	3.2
Oct	21	19	3.2	0	0.1	3.3
Nov	23	17	2.3	0	0	3.4
Dec	26	14	2.3	0	0	2.9
Mean Annual	20.41	18.91	2.80	0.016	0.03	1.85

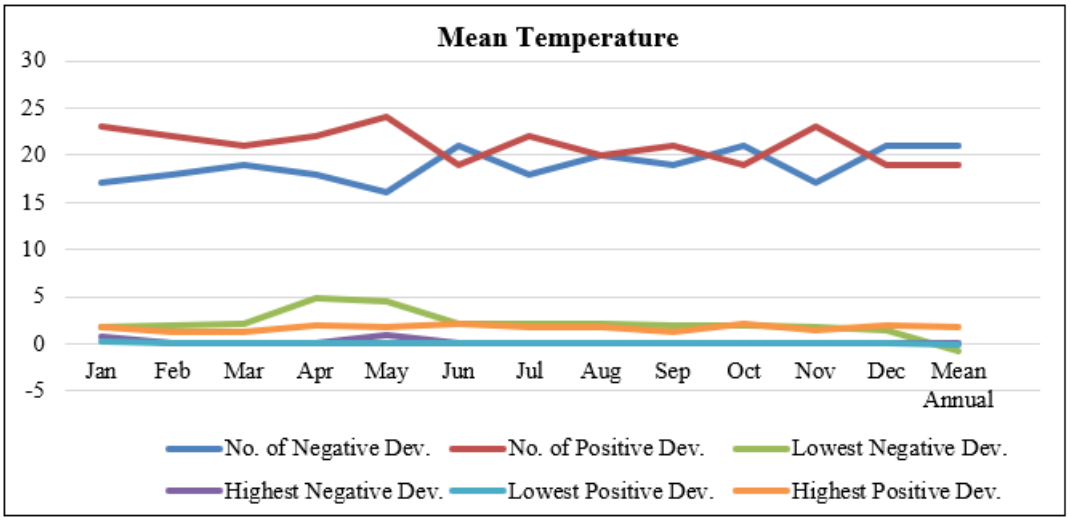


Graph 1

Mean Temperature

Table 3

Month	No. of Negative Dev.	No. of Positive Dev.	Lowest Negative Dev.	Highest Negative Dev.	Lowest Positive Dev.	Highest Positive Dev.
Jan	17	23	1.8	0.7	0.2	1.8
Feb	18	22	1.9	0.09	0.1	1.2
Mar	19	21	2.1	0.04	0	1.3
Apr	18	22	4.9	0.08	0.1	2
May	16	24	4.5	0.9	0	1.7
Jun	21	19	2.2	0	0.1	2.2
Jul	18	22	2.2	0	0.1	1.8
Aug	20	20	2.1	0	0	1.8
Sep	19	21	2	0	0	1.3
Oct	21	19	1.9	0	0	2.1
Nov	17	23	1.8	0	0.1	1.5
Dec	21	19	1.5	0.03	0.1	2
Mean Annual	21	19	-0.83	0.15333333	-0.02	1.85



Graph 3

During the summer (coloured as red), the Maximum Temperature is recorded to be deviating positively by0.11°C to 2.39°C for 21 to 22 months and the Minimum Temperature increased by 0.01°C to 4.30°C for 18 to 19 months. In contrary Temperature decreased by 0.01°C to 6.70°C the Maximum for 18 to 19 months and the Minimum Temperature also declined by 0.01°C to 3.51°C for 21 to 22 months. This implies that nearly half of the total study period, the summer months were either too hot or cooler than the normal summer. But looking at the Mean Temperature, it's clear that, 22 to 24 summer months showed a positive deviation of Mean Temperature from 0.03°C to 2.05 indicating the summer were hotter than the usual and 16 to 18 summers were apparently cooler as the Mean Temperature decreased by 0.09°C to 4.94°C.

Its observed during the two Monsoons (coloured as red) the Maximum Temperature deviated positively by 0.01°C to 3.23°C for nearly 19 to 23 years but the Minimum Temperature showed 0.01°C to 3.45°C increase for 17 to 19

years. This indicates that most of the Monsoon months remained hotter than the usual. In reverse the Maximum Temperature decreased by 0.01°C to 3.96°C for 17 to 21 years and so the Minimum Temperature also declined by 0.02°C to 3.21°C for nearly 21 to 23 years. The Mean Temperature also recorded to be increasing by 0.01°C to 2.26°C and decreased by 0.02°C to 2.28°C for 19 to 23 and 17 to 21 years respectively. Overall looking at the deviation of Annual average Maximum and Minimum Temperature (coloured as yellow), it can be exactly said that nearly one-third of the total study period (14 years), the District suffered hotter, one-fourth of the period (10years), cooler and rest of the 16 years the climate was dynamic since the Maximum and Minimum Temperature are reported to be positively deviating for 30 and 14 years (common 14 hotter years) respectively. Whereas, the negative deviation for both is recorded for 10 and 26 years (common 10 cooler years) respectively. Finally, from the limits of the deviation of the Mean Temperature in the table above and the deviation of Annual average Maximum, Minimum and Mean Temperature from the Normal for 40 years which is illustrated in the graph (GRAPH 1), shows 19 years positive deviations, while the years 1981-83, 1989-96, 1999-2000, 2005-08 and 2014-18 have shown apparently negative deviation from the Normal. Very unlike the precipitation variation, the temperature also showed a continuity of positive or negative variation for 3-4 times. 1979-80, 1984-87, 1997-98, 2001- 03 and 2009-13 are the continuous hotter years consisting of a set of 2-4 years in a row as the deviation was positive from the Normal. And hence, a continuation of apparently colder years were also observed. Hotter weather in a sequence, result more surface evaporation leaving the agricultural lands dry and unpredicted sudden heavy downpouring causing more runoff, erosion and flood. On the other hand, continuity of cooler weather the other hand, years results less surface evaporation causing less precipitation resulting continuous drought for the successive year or years.

Table 2: Month wise & Annual average Deviations & Variance of Mean Temperature from the Normal in karimnagar

Each monsoon month i.e. June to December, the variance shows positive which means overall these Monsoon months (orange shaded columns) always were hotter than the Normal, hotter weather years face unpredicted precipitation. Here, it is to be understood that, hotter weather is expected in summer months instead of the months of monsoon season. As the graph shows the average deviations for these monsoon season months are positive, this means on an average the whole 40 years were apparently hotter than before and the precipitation received was also comparatively less. This is a big challenge for the agricultural producers in the District.

Rainfall Deviation in Karimnagar: Since Temperature is the cause and Precipitation is the effect, it's obvious that the rainfall will be unpredicted when the temperature has a temperature has a dynamic variation in every alternative year. In this district, the rainfall distribution during the two monsoon months and the deficit months which below Normal were having precipitation over a period of 40 years can be clearly identified from the table below (Table 3). The study reveals that the Normal rainfall received by the district during South-west Monsoon is nearly5 times higher than the North-east Monsoon. Apart from that, the district received below Normal rainfall for 22 years during southwest monsoon season and 27 years during northeast monsoon season. Northeast monsoon seems to be more erratic than the southwest in case of this district. Nearly three fourth of the total 40 years of period received less precipitation than the Normal. This is absolutely a hopeless assurance for Agriculture. Out of 40 years only seven years i.e. 1979, 1981, 1983, 1995, 2005, 2008 and 2017, the district received higher rate of Precipitation. The remaining 33 years were apparently dry which received either near Normal or below Normal rainfall as a whole. July, which is the second month of South-west Monsoon, except for the years 1982, 1983, 1989, 2005, 2010, 2016, and all the other years showed negative mean deviation. Coming to August, the third, and September, the last month of South-west Monsoon, it is observed that there is a positive deviation for the month of August, it immediately became negative for the month of September.

Potential Evapotranspiration (PET)

Potential evaporation (PE) or Potential Evapotranspiration (PET) is defined as the amount of evaporation that would occur if a sufficient water source were available. If the Actual Evapotranspiration (ET: The sum of evaporation and plant transpiration from the Earth's land and ocean surface to the atmosphere) is considered the net result of atmospheric demand for moisture from a surface and the ability of the surface to supply moisture, then PET is a measure of the demand side. Surface and Air Temperatures, Insolation (Solar irradiance is the power per unit area received from the Sun in the form of electromagnetic radiation in the wavelength range of the measuring instrument. The solar irradiance integrated over time is called solar irradiation, insolation, or solar exposure. However, insolation is often used interchangeably with irradiance in practice), and wind all affect this. A dryland is a place where annual potential evaporation exceeds annual precipitation. For this research, The PET is estimated using the C. W. Thornthwaite's method 91948). The equation for estimation as follows:

Thornthwaite's Equation (1948):

PET=16(L12) (N30) (10Tal)

PET:

The Potential Estimated Evapotranspiration (mm/month).

Ta: The Average Daily Temperature (oC; if this is -ve, use 0) of the month being calculated.

N: The number of days in the month being calculated.

L: The Average Day Length (hours) of the month being calculated.

a: (6.75 × 10-7) 13-(7.71 x 10-5) 2 + (1.792 × 10-2) I +0.49239

I: E(Tai5)1.51412i-1 is a Heat Index which depends on the 12 monthly mean temperature.

Potential evapotranspiration is mainly driven by the density of vegetation canopy, quantity of surface water as well as precipitation, temperature, wind and vapor demand of the atmosphere. After a complex calculation, Monthly to Annual, Decadal and then the Normal of Potential evapotranspiration was calculated for both the districts.

Potential evapotranspiration in Karimnagar: The decadal averages of the Potential evapotranspiration from 1979 to 2018 for the district are given in the map. It is seen that the Potential evapotranspiration kept on increasing diagonally from North-east to South-west in every decade. The spatial pattern of Mean Annual Potential evapotranspiration for each decade which describe that for the years 1979- 88, 1989-99, 1999-2008 and 2008-18 the rate of Potential evapotranspiration was very high in the Southern and South-western regions. The reason was very obvious as the South and South-west regions covering Metpelly and Ramagundam mandals always received below Normal rainfall, hotter weather with no or less vegetal cover and unprotected openly available surface water. A comparative study of the Annual Mean Temperature Deviation, Annual Mean Precipitation and Annual average Potential evapotranspiration reveals that the trend of Potential evapotranspiration was always parallel with the deviation of mean temperature but the Precipitation showed opposite trend for most of the years and that is in a consecutive manner. This means, when there was a positive deviation of the Temperature, Potential evapotranspiration was more but for most of such years the Precipitation was erratic. Also, it can be seen on the that the Potential evapotranspiration was always much higher than the Precipitation in the District. The order of Precipitation was also most often opposite the and Potential Temperature evapotranspiration.

To the If Potential evapotranspiration is more the Precipitation is less. This is the most addressable problem that caused the southern and south-western regions Drier and hotter resulting drought. This paper attempts to use the Mann Kendall method to trace out spatial and temporal trends of three climate parameters between the years 1979 and 2018 in Karimnagar district of Telangana. This study helps in comprehending two aspects. One is the climatic context of the region that has been subjected to severe iridization's in the past 40 to 50 years because of changes in the regime of the parameters. Secondly as far as methodology is concerned it tries to make an exhaustive climatic trend analysis.

Temperature Trends: Based on the analysis of temperature of vectorized gird method results an overall temperature increase was noticed over four decades especially during summer months. Almost 34 years out of 40 years of study the temperature was above normal except for 1990, 2013-2018. For a concrete quantification of mean temperature changes, thermal regime dynamics were analyzed on annual seasonal and monthly basis, The Mann-Kendall test results for each analysis scale is shown in graph 4. Annually, in the years 1972, 1995 to 2010 and 2015 the temperature showed upward trend, the average temperature considered. Seasonally, the temperature trend has shown certain specificities for each season, the trend showed a decrease in monsoon season during the years 1979, 1989, 1999, 2010 to 2015. The summer season has shown an upward trend by an increase of 1° to 2°C. The monthly period that was analyzed displayed a more vivid trend dynamics for temperature.

Precipitation Trends: Based on the analysis, the vectorized grid results for annual revealed a general decrease in precipitation almost in all the years except 1979, 1983 to 1986, 1991 to 1994, 1997, 1999 2001 to 2004 and 2012 to 2015 (Fig. 3b). The district receives most of the rainfall during south west monsoon season. It is observed that the month of June (Pre period) doesn't show show rainfall monsoon fluctuations, rather it is observed nearly every 4 to 6 years interval there is a dry spell. During the period of south west monsoon an increase or decrease of dryness and wetness is rhythmic though the consecutive three months i.e.., July, August and September or in other words if July starts with extremely dryness by the end of September it reaches to near normal then by September it ends with dry spell. Hence the south west monsoon for Karimnagar is somewhat dependable for agriculture purpose. During the North east monsoon season i.e.., October to December, the rain is unpredictable as it lingers only for a shorter period. So not only the rainfall is less but also irregular. If October is dry, then November is unexpectedly wet and vice versa.

Potential Evapotranspiration Trends: An analysis of annual rainfall distribution along with temperature distribution, it can be described the strategy of potential Evapotranspiration throughout the district for every individual year. Potential evapotranspiration is mainly driven by the diversity of vegetal canopy, quantity of surface water as well as precipitation and the temperature. The district has shown increasing trend in Potential evapotranspiration; the reason was obvious as the district received below normal rainfall and the temperature was high with no or less vegetative cover and less available surface water. The overall assessment of the temporal dynamics of the study reveals increasing trend during summer season especially during May month in almost all the 40 years. Ranging from 511.87mm to 47.32mm. This is largely influenced by temperature dynamics. A detailed three scale trend analysis revealed peculiarities for these parameters as well annually, the weather station recorded upward Potential evapotranspiration rate trends. However, during monsoon season the trends were observed to decrease. The study brings out the fact that the climate water deficit has increased over the years because the potential evapotranspiration trends showed dependence of agricultural systems on climate condition in the study area under consideration has brought about fluctuations in agricultural yields because of the breakdown of irrigation systems and the resultant climatic water deficit. The analysis of all the three climatic parameters has shown that an increasing trend has had an indirect impact on decline of yield for many crops in the district. Even the ecology surrounding the study area has come under the climatic change induced pressure.

5. Conclusions

The objective of this study was to analyze the annual, seasonal and monthly dynamics of the climatic parameters' temperature, precipitation and potential evapotranspiration quantities in the Karimnagar district of Telangana state during the period 1979 to 2018. The Mann-Kendall statistical test was used to analyze the climate data derived from Karimnagar station. The following features of each climate parameter's dynamics were observed from the data analysis made:

1) The temperature analysis displayed upward trend for annual, seasonal periods. The monthly temperature instances showed positive trends and exhibited

decreasing temperatures for the months of October to February. higher rates when an analysis of the.

2) Compared to temperature, rainfall displayed parameters temporal dynamics was made and having compared the results to variations in rainfall. Only the post monsoon period was an exception as in this season excess climatic water is recorded which resulted because of increased rainfall and less of evapotranspiration The rates. Excessive more acute dynamics. A downward trend was seen in the annual ad seasonal precipitation.
3) Potential evapotranspiration had more or less the same dynamics as temperature. As far as Potential evapotranspiration increased rates, it was observed that in a few years, it exceeded annually and seasonally.

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