Major Project Report On

"Trend analysis Of Precipitation & Temperature pattern for Konkan Division of Maharashtra, India"

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submitted by

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DECLARATION

I, Shivang Mathur, Roll No. 2K20/ENE/11 student of M.Tech (Environmental Engineering), hereby declare that the project Dissertation titled "Trend analysis Of Precipitation & Temperature pattern for Konkan Division of Maharashtra, India " which is submitted by me to the Department of Environmental Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is originaland not copied from any source without proper citation. This work has not previously formed the basis for the award of and Degree, Diploma Associate ship, Fellowship or other similar titleor recognition.

Place: **Delhi** **Shivang Mathur**

Date:30/05/22

CERTIFICATE

I hereby certify that the Project Dissertation titled "Trend analysis Of Precipitation & Temperature pattern for Konkan Division of Maharashtra, India" which is submitted by **Shivang Mathur**, 2K20/ENE/11, Department of Environmental Engineering, Delhi Technological University,Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge, this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

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Shivang Mathur

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ABSTRACT

The significant objective of the present study is to examine trends in rainfall and temperatures in all seven districts of the state of Maharashtra. Maharashtra is an Indian state along the western coast of the sea. This study examined seasonal and annual precipitation trends, minimum and maximum temperature and their fluctuations in the Konkar division of state from 1981-2020 (41 years) in terms of spatial and temporal homogeneity .The vulnerabilities were examined and analysed using mathematical and statistical trend analysis techniques such as the Mann–Kendall test and Sen's slope estimator .There are increasing trends in some months based on precipitation and temperature, and no trends for some months based on temperature and precipitation for all seven districts in Maharashtra .Over the course of 41 years, the research has found a considerable increase in both seasonal and annual rainfall.

Keywords: ***Rainfall, Mann-Kendall trend test, Sen's Slope, Kendall's tau***

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CHAPTER 1

INTRODUCTION

Temperature changes have been studied extensively and are well understood on a vast variety of time scales. According to the National Climate assessment Commitee I's Fifth Assessment Report, worldwide averaged soil air temperature has risen by 0.72 degrees Celsius from 1953 to 2017, with the biggest warning effect occurring since the 1970s (IPCC, 2013). However, global and regional liquid precipitation patterns are a few clear. Water droip has fallen and increased in the tropics (30 degrees N to 30 degrees S latitude) during the 1970s; precipitation has increased in the recent years (2000s), overcoming previous drying trajectory seen from the 1970s to the late 1990s (IPCC, 2013).

Water is necessary for all living things to exist. It is a critical aspect for agricultural and industrial development and expansion, especially in the wake of rising rapid urbanisation. Climate change and its instability have the capacity to alter the region's hydrological cycle and hydrological regime, as well as have a direct impact on water supplies. As a consequence, it is vital to examine the effects of climate change on hydrology and water resources. Monitoring and measuring the many features of the hydrological events that occur within the region of interest is critical for managing water management challenges. Impact assessments are typically done by creating a model validation watershed climate models and analysing the results.

The raimfall and temperature (Singh et al., 2013) are fundamental physiologic parametres among the local climate. These precipitations are part of hydrological and changes of its pattern directly affect the water energies. The magnitude of the variability or fluctuations of the climpact varies according to locations. All there where is changing nature of rainfall as a result of climate change is causing problems for water management and other resource managers. Rainfall quantity and frequency changes are directly related to stream flow pattern and demand, spatiotemporal allocation of run-off, ground water reserves, and soil, which contains all other characteristics such as moisture.

As a result, for various formats of examining the spatial and tempority dynamical structure of meteorological variable is to the contextual of changing climate, originally. In the country where rainfed agriculture is practised. Is an important trend, as it is vital to identify climate-induced changes and suggest possible solutions. Adaptation of all the many strategies that are As a result, these alterations revealed the extensive ramifications on the water resources, Environmental resources, tropographic resources, and terrestrial resources are all examples of resources. Ecosystem, ocean, bio-hazardous, agricultural, and food are only a few examples. Security Because of Changes in the pattern, frequency., and. variability of the SW monsoon, drought and food similiar dangerous event can occur regularly. (Sinha& Srivastav, 2000; Seo and Umenhofer, 2017.)

The pattern and amount of the rainfall (Gajbhiye et al., 2016) are between of the most true factors that are carrying changes in our land agricultural production. Agriculture and other related sectors, food security and energy security of any region (Modarres and da Silva, 2007; Kumar and Gautam, 2014) are crucially dependent on the timely availability of adequate amount of water and a conducive climate. The model is capable of simulating different different hydrological processes, including projected hydroclimate variations, taking into variations, taking into account future climate forecasts (Neitsch *et al.*, 2011).

The biggest impedimentially for the successful water resource treatment processing qlulaity management in India is the uneven distribution of water supplies across our native country due to the natural pttern of rainfall occurrence, which varies in largely in area and time. Climate change is hastening towards of different kind of the variability in monsonal rainfall that posses a thin accesibility . As a result, many parts of the country receive a lot of rain during the monsoon, while others part od the socaillty get a very littlebit of rain and frequently face the worst case scenarios of aquatic water and land scarcity .

The amount of water availablilty to meet diversifiy demands, such as agricultural, industrcial, domestic water supply, and hydroelectric power generation, is determined by the amount of rainfall received in a given location. As Rainfall feeds more than 68.0 percent of the State's cultivated area, and rainfall is the most important agroclimatic variablilty that determines annual and traditional growing method of crop production in coastal division which is konkan divison of maharashtra.

Therefore, the need for continuous rainfall studies is to be emphasized for the purpose of long-term water resources management and overall economy of the country (Saha and Mooley, 1979). The non-parametric test like Mann-Kendall test and Sen's slope estimation was applied to detect the trend in rainfall and to analyse and forecasts the long-term Spatial-temporal changes in rainfall using the data from 1981 to 2020 in Konkan division of state at meteorological divisional level. The core objectives in these analyses were to examine fluctuations and trends in precipitation and minimum & maximum temperature for the time interval of 1981-2020 in Maharashtra state.

This study is to investigate the variability of the rainfall and temperature of Konkan division, which is the coastline region in the state of Maharashtra and India. Seasonal trend of both the parameters has been investigated on an inter-annual basis and the fluctuations has been calculated on monthly basis with major focus on monsoon season (June– September). The significant long-term trend has not been detected in monsoon rainfall on a national scale. Results show the trend analysis in monthly, monsoon seasonal and annual rainfall over Maharashtra and reported that long-term significant positive trend was tested in annual and monsoonal rainfall in 5 out of 7 districts, while the negative trend was detected in 2 out of 7 districts.

Understanding the uncertainties with rainfall and temperature patterns will provide a knowledge base for best management of agriculture, irrigation and other all aquatic related activities in the selected area.

1.1. Climate Change and its General Impacts

Climate change is occurring due to various causes such as by both of the actions like natural and human actions, particularly all those activities that modifies the composition of atmosphere's chemistry aee likely to be the full drastic cause of change in natural habitation. Climate change is characterised by a complex mix of stressors that include rising drastic atmospheric greenhouse gas (GHG) and there concentration on land and air and even many types of water bodies, and in increased of there frequency and intensity of extreme weather events, and changes in temperature, precipitation, and hydrological and hrographical cycles, among others (Durdu, 2010).

Deforestation is the cutting of trees and shrubs which should not be done so quickly , industrial operations such as new industries of food and material productions, agriculture-related processes like organic farming and packaging of different food items, and, most crucially, the burning of coals and hard fossil fuels are all examples of human anthropogenic activities that have a large contribution in increasing of GHG levels (UNFCCC, 2006).

Since the beginning of the Industrilisation and Revolution, increased carbon dioxide concentrations in the atmosphere have been reported. Since then, there are many large scale changes to be considered that occurs in our surrounding areas such as agricultural, manufacturisaton, coal mining, transportation, and modern science technology, may caused resulting in demand of increasing fossil fuel consumption .It is widely stated and suspected that in these any kind of circumstances may lead of accelerate in temperatures (Scavia et al., 2002). The Intergovernmental Panel on Climate Change (IPCC) reported a 0.56^{o}C to 0.92^{o}C increase in mean surface temperature from 1906 to 2005 and in its most current assessment (IPCC, 2007).

This increase is greater than the previous IPCC report, which said that the global mean surface temperature increased by around 0.3 to 0.6 degrees Celsius between 1901 and 2020. (IPCC, 2001). Many government bodies are already working on it around the globe are instituting different emissions caps, carbon trading of carbon credit schemes, and the use of cleaniness, renewable energies resource like wind and solar power to figure out how to prevent climate change.

All of the sudden fraction changes in the climate may threaten the global freshwater system and by rise in all the uncertainty which is associated with hydrolographic processes (IPCC, 2007; Koutsouris et al., 2010).

1.2. The Economics Of Climate Change

It is more difficult for developing countries to catch up with developed countries when faced with a rapidly growing developmental process, especially when climate change issues are present, and it is even more difficult for India, as compared to other countries, because poverty is the most powerful force pushing it back. Dealing with global warming challenges is a difficult task for Indian scientists and economists who must foresee future developments, as well as policymakers whom most unltimately chase policies those balance risks and money. Marging the Global Command is a alone endeavour to integrate ecomomic, sceintific, and policy excepts of these huge geoditical experiment.

Managing the GIobal Commons includes a thorough examination as well as a thorough examination of the modell's outcomes. DICE is one of the only first of dymanic model to contain a closed clircle system which is form that takes into account enissions, concentreations, cIimate change, dangers, and emissiom restrictions. The modeI can be used to calculate the costs and advantages of various techniques for slowing climate change, as well as to examine the impact of control strategies over time (Devesh et al 2009).

1.3. Global And Regional Climate Change

There are several indicators in the oceans and atmosphere which gives warning time to time to the world of increment of pollution level (Hartmann et al., 2013). These warnings are in forms of oceanic temperatures, glaciers, snow cover, rise in sea level, atmospheric water vapour, several events and ocean acidifications.As per the theory of Bindoff et al., (2013), according to the assumption of previous cIimate form paIeo-climate properties shows these prior drastic diffeences in overall world surface temeperature are remarkable all these are only naturaI transitions cannot easily explain the fasten rate of warming in the industrial time period. Most of the models which are mainly based on computer are also not able to repIicate the taken for granted gIobal warming in useless for all the consequences of human induces change like emissions of Greem House Gasses and aerosoIs, and changes in use of Iand and Iand cover is incIuded in it.

In the process of forming of climate change policy framework, the key terms are worldwide land surface air temperature (LSAT) and sear surface temperature (SST) where both comprise with the Global Mean Surface Temperature (GMST). On comparison to any other global apparatus, GMST has a longer historical record which makes it very essential for determining of climate patterns and magnitude of natural climate changes as shown in figure below.

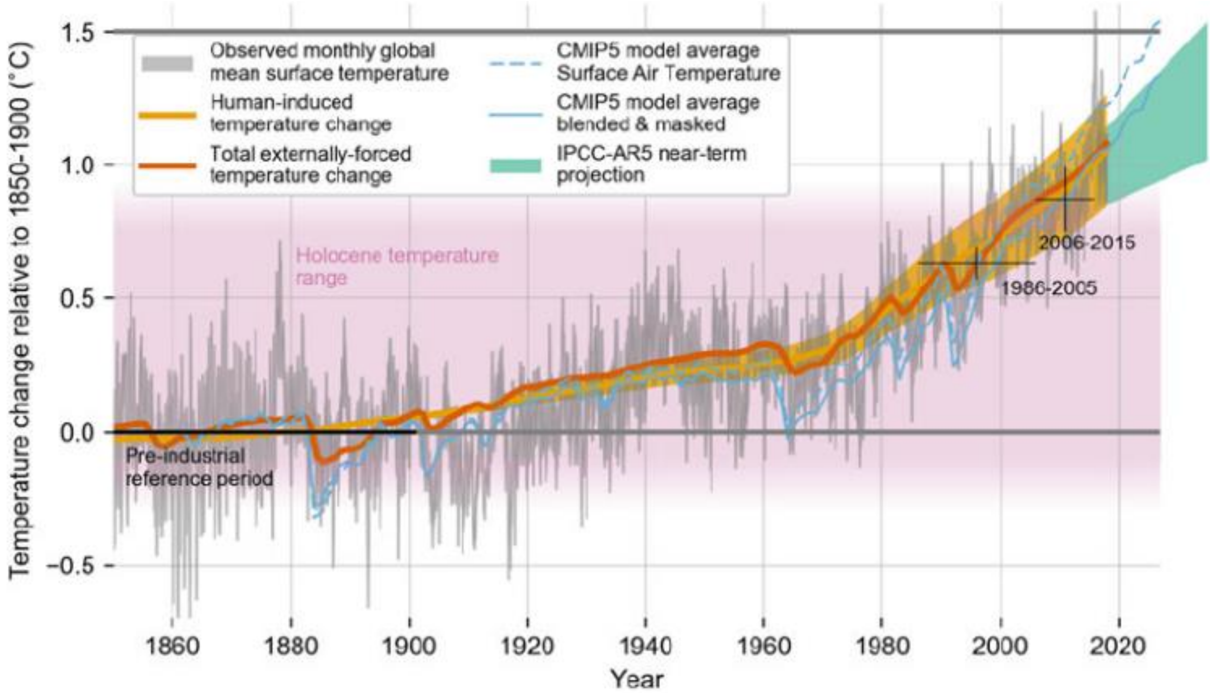

Figure: EvoIution of "gIobal mean surface temeperature AGMST Lover the periodic of instrument?" observational. Grey and blackish shaded straight confomatry line gives us the monthIy mean GMST in the HadCRUT4, The pimk shading delivers a traffic range for temeperature fluctuations over the Holocene Olaycott et aL 2013). Light greem plumne shows the ARS logical precipitation for average GMST over 2016-2035 irtinan et aL 2013.

1.4. Projected Changes in Global Climate

Climate models are mainly define as the response of the climate system to androgenic activity which is also sometimes referred as external forcing. On the path of research about the change in climate, various basic scenarios have been evolved with particular description of how human induced changed would influence the total energy of the planet. As per the theory of Calel and Stainforth (2017), Assumptions of future changes and consumption of fossil fuels, lamd use etc are basically due to the development by using combined asset modeIs that include economic, demologic and policies modeling as well with complete physical climatte models to replicate all same consequence of gIobal economic impacts of change in climate under various situations.

1.5. Synthesis of Regional Climate Change

.Between 1901 and 2021, the temperature of the surface air over India increased by around 0.7 degrees Celsius. Observations, reanalysis datasets, and climate model simuIations all show unambiguous signs of human linduced climate change over the Indian subcontinent in recent decades. Anthropogemic GHG and aerosol focusing, as well as changes in Iand use and land cover, have all comtributed to these shifts (e.g. Krishnan and Ramanathan 2002; Dileepkumar et al. 2018).

Future climate projections for the Indian subcontinent and neighboring areas show significant changes in the mean, variability, and extremes of several key climatic parameters, such as Iand temeperature and aquatic, monsoons, lndian Ocean temperature and the mean sea leveI, tropicaI cycIones, Himalayan cryosphere, and so on, under various climate change scenarios.

1.6. Response to Climate Change

While many scientists agree that it is too late to prevent some of the early effects of climate change, practically everyone agrees that the process may be reversed by slowing global warming. The only way to achieve this is to stop emitting more carbon dioxide into the environment than the atmosphere can naturally absorb. This would require a 60 percent reduction in global greenhouse gas emissions, which is a huge amount when you consider the development rates of developing countries like India and China, as well as the energy consumption of wealthy countries like the United States. To figure out how to prevent climate change, many governments around the world are instituting emissions caps, carbon trading schemes, and the use of clean, renewable energy sources like wind and solar power; many governments are instituting emissions caps, carbon trading schemes, and the use of clean, renewable energy sources like wind and solar power

Traditional forms of energy, such as coal and oil, are thought to contribute to global warming; therefore these solutions may force an energy industry reformation. Reducing emissions necessitates reducing the world's reliance on fossil fuels for energy, which is a difficult transition given that fossil fuels are far more cost-effective than present renewable energy sources. Several countries, including Japan, Europe, and USA, have already taken the lead in adopting modern energy policy norms and encourage other countries to follow suit; additionally, the time has come for the energy market to move from its existing position.

1.7. Policy Options

After all of these lengthy debates, one thing is clear: the development of new policies, as well as adjustments to the current policy framework, is now an unavoidable requirement of the hour. India has long been known for its people-friendly laws, stretching back to a time when even today's developed globe, particularly the west, was nothing more than a food gatherer society.

The principal strategist of the Mauryan Kings, Acharya Chanakya or Kautilya, is known for the Arthashastra or Book of Economic Policies, a famous treatise. He has proposed a number of initiatives for the state to implement in order to benefit the subject. Surprisingly, he has placed a greater emphasis on water and environmental measures than on any other. He has boldly stated that a just monarch's first duty is to protect water sources, and that this should be the yardstick by which any empire's capability to be or remain a king is measured (Shabbir, S., 2012). Apart from climate change, India has worked for decades to improve the poor performance of its energy industry. A number of commissions and reports have advocated for nationwide reforms to improve transmission and distribution efficiency, implement demand-side management programes, reduce auxiliary consumption at power plants, and establish an independent coal mine regulator to address the industry's current inefficiency. Certain expenditures, when there is increament of such as coal fired power plant efficiency, building ultra and supercritical plants, and programmes to improve the efficicacy of existing plants, will not be justified on cost and efficiency alone, according to Devesh et al., unless there are many subsidized sdded by additional and extreme and ultimate resources (2009). There is a little consequences which the suitable reason why as a part of India . this country cannot design and implement any kind of an effective and solid programme to reduce feasible local emissions with associated qulalities of health structure and there benefits at the household levels and reduced the amount of soot emissions at every level of state , at level of districts and at the national level in most senarios, such as more cooking facilities increases the efficient of native cooking stoves for rural houses , in which they have to struggle on it to provide the best to them.

1.8. MANN KENDALL TEST

The Mann-Kendall Test is used to see if a time series is progressing higher or downward monotonically. The information does not have to be regularly distributed or linear. It does necessitate the absence of periodicity.Further a linear tend was added as parametric test. Non parametric Mann-Kendall test was also performed by the Sen's slope estimation method.

null hypothesis is that there is no trend, while the alternative hypothesis is that there is a trend in the two-sided test or an upward (or downward) trend in the one-sided test. The MK Test utilises the following figure for the data series x1

,..., xn.

The MK statistic S is defined as follows to detect trend in a rainfall time series, presuming that the time series is independent:

$$S = \sum_{i=1}^{n-1} \sum_{j=i=1}^{n} \operatorname{sign}(x_j - x_i) \qquad (1)$$

where *x* and *x* are sequential data for the *i*th and *j*th terms; *n* is the sample size; and

$$\operatorname{sign}(x_j - x_i) = \begin{cases} +1, & \text{if } x_j - x_i > 1 \\ 0, & \text{if } x_j - x_i = 0 \\ -1, & \text{if } x_j - x_i < 1 \end{cases} \qquad (2)$$

The statistic *S* is Gaussian when $n = 18$ with the mean $E(s)$ and variance $\operatorname{Var}(S)$ of the statistic *S* given by the expressions:

The Mann Kendall z-statistic is written as

$$Z = \frac{|s|}{\sigma^{0.5}} \qquad (3)$$

1.9. Objectives of the Study

The primary objective of the thesis are:

The basic aim of my study to investigate and research the previous four decade of rainfall and temperature data of seven districts of maharashtra by using techniques namely Mann–Kendall test and Sen's to analyze the problems accurately predict.

CHAPTER 2

LITERATURE REVIEW

Major changes in the Earth's climate characteristics are expected as a result of human activity. Climatic models aid in the comprehension and prediction of future climate activities. Changes in runoff are widely recognised as a result of the cumulative effects of climate, land cover, and human activities. Precipitation, maximum and lowest temperatures are the primary meteorological elements that influence the hydrologic of a watershed. As various processes inside this watershed have an influence on water sustainability and farming practises, a climate change impact assessment of watersheds is required.

Arpita & Netranandra (2019):

The current study looks at long-term trends and short-term variability in southwest monsoon rainfall and temperature in Odisha's Kalahandi, Bolangir, and Koraput (KBK) districts. This study looked at both rainfall and temperature data from 1980 to 2017. The annual maximum and minimum temperatures have exhibited an increasing tendency over the last 37 years.For the JJAS season, rainfall is increasing steadily (Sen's slope = 4.034). The maximum temperature trend for the observed period showed a slight warming or increasing trend (Sen's slope = 0.29) while the minimum temperature trend showed a cooling trend (Sen's slope = 0.006). . One of the KBK districts is one of the rearmost regions of Orissa and India. season .This includes understanding precipitation and temperature trends in the region.

Sarita & Chandrashekhra (2018):

The think about of long-term precipitation record is basically imperative for a nation, In these, the authentic 101- year (1901–2000) precipitation information of basin Sindh Stream bowl (SRB), India, were analyzed for seasonal and yearly patterns. The Mann–Kendall test and Sen's slant show were utilized to identify the drift and the size of the alter, separately. The examination uncovered the essentially expanding precipitation drift in both seasonal and yearly precipitation within the span of 101 .

The in general examination demonstrated an expanding trend in the precipitation of SRB amid the storm seasons. From all the factual test comes about, it can be concluded that there's prove of some alter within the slope of precipitation in span of 102 years.

Arun & Sanand (2012):

This locality is located in the northern and east part of kolkatta district in Orissa state of India. Geographically, it is situated at 20°37´ N latitude and 86°9´ E longitude and it is in the local basin of Mahanadi river. The area falls under monsoon climatic up and annual temperature lies between from 13ºC to 37ºC and annual rainfall lies from 115cm to 120 cm. Trend analysis of Birupa basin from where the river flows has been taken in the present study of 40 years of precipitation is taken from 1983 to 2015. Mann-Kendall and Sen’s Slope Eluminator is used to check the trend represents the natural precipitation of 40 years with top rainfall occurrence in the annual 1983 with the total drop of waterfall of 2720 mm nearly and minimum drop of water has occurred in the year 1994 with the total amount of 1318 mm. Average rainfall is limited for the areas within these 32 years is 163.76 mm.

Reshu & Pranuthi (2020) :

The current research focuses on the trasitioning of trends in rainfall and temporal throughout the districts that are there in Uttarakhand state. The state is situated in the most of the southern slope of the Himalayan range, It also varies the climates and shrubs depending on elevation. The study used daily rainfall data from 1971 to 2011 and minimum and maximum temperature data from 1971 to 2007 to determine the monthly variability of rainfall and temperature for which Mann-Kendall regression was used (MK). In 13 districts of Uttarakhand, researchers analysed precipitation (41 years) and minimum maximum temperature (37 years)variability and detected patterns in the yearly, monthly, winter, pre-monsoon, monsoon, and post-monsoon seasons. Similarly, in high altitude places, a drop in all annual maximum temperatures and a 99.9% increase in minimum temperatures will be beneficial to the crop, while in plain areas, the effect will be the opposite.

Pranuthi (2020) :

Analysts have done a few studies in order to determine the regional and temporal variability of precipitation. Singh et al. (2018) provided a thorough rainfall which is drift for the N-W region of India, which includes Punjab, Haryana, Delhi, Himachal Pradesh, and J&K. Rao et al. (2011) found no such work for Parbhani, thus this study was conducted using precipitation data from the All India Facilitated Extend on Agrometeorology over a 30-year period (1987-2016). Pre-monsoon (March-May), monsoon (June-September), and Post-monsoon (October-December) were the four seasons identified (January-February).The atmost recent investigation which os done on the trend , it can be concluded from these trends that, precipitation in the peak time of monsoon and post storm season has non significant decreasing slope.

Anirban (2020) :

Using Mann-Kendall analysis, this study indicates changes in yearly and monthly monsoon data gathered from 39 stations over 32 years (1981-2012) in the Seonath river basin, Chhattisgarh, India. The Seonath (also known as Shivnath) river basin is located in Chhattisgarh's lush plains. This basin is located between the latitudes of 20° 16' N and 22° 41' N, and the longitudes of 80° 25' E and 82° 35' E. The basin encompasses much of the upper Mahanadi valley. Seonath is the Mahanadi's longest tributary, with a length of 380 kilometres. Its source is in the Rajnandgaon district, near Panabaras town.

Trend analysis of monthly and annual rainfall data for Seonath river basin, Chhattisgarh, for 32 years (1981-2012) using Mann-Kendall and Sen's slope estimator test.

Neeraj et al., (2016) :

The Extreme occurrences appear to be occurring with greater regularity in recent years. The total cropping pattern, productivity, and stability of an agriculture enterprise are all governed by rainfall patterns. Although the subject of environmental issues is broad, the changing nature of rainfall is one aspect of it that requires immediate and deliberate action since it affects both fish stocks and agricultural production (Dore, 2005). In India agriculture many parts of Asia, In the southwestern and central parts of Ethiopia, Wing Cheung et al. (2008) discovered a considerable decrease in June to September rainfall (i.e., Kiremt) for the Baro-Akobo, Omo-Ghibe, Rift Valley, and Southern Blue Nile watersheds.

Vinushree et al. (2022) :

Groundwater plays a significant part in addressing India's water demands in numerous sectors. Groundwater overexploitation is becoming a big concern in the country. As a result, detecting trends in groundwater storage is critical for groundwater resource management. The current study was conducted in the 24 observation wells in the Dharwad district of Karnataka because of the relevance of groundwater. In the month of April, the greatest strong positive slope occurred at W15, Wani et al. (2022)

The Mann-Kendall test and Sen's slope estimator were updated to analyse the problem using annual and monsoon time series data from 1981 to 2010.

Pramodkumar (2018) :

Long-term yearly rainfall records for 12 rain gauge stations in the basin were used to examine the data for this study. Except for Surgana Station, where data was only available for 50 years, the data was available for further than 100 years. For the Par Basin, Mann-Tau Kendall's () is 0.067. The positive result indicates that the rainfall pattern over time is increasing. Despite the positive outcome, the application of this probabilistic methods to the basin's yearly rainfall data reveals no significant trend at the 0.01 and 0.05 levels.

Vishal et al (2020) :

The purpose of this study was to look into and evaluate the prospective trend of rainfall and wet conditions in the Tasgaon tahsil in Maharashtra's Sangli district. In this study, line graph for rainfall and rainy days was performed on an annual, annual, and regular basis utilising data from 1961 to 2018. Sen's slope estimator test was used to determine the trend directionality of change over time. Mann-Kendall test and Sen's slope prediction test were used to understand the main trend direction. For annual, seasonal, and monthly (May to November) time series, the test findings demonstrated a declining rainfall and heavy rain trend out over Tasgaon tahsil. It is located between the latitudes of 16°5'N and 17°33'N latitude and 73°41'E to 75°41'E longitudinal. The climate of Sangli district is usually hot and dry.

Neeraj et al., (2016) :

In the south Asian region, various precipitation trend studies were conducted. (Marco et al. 2003) found that the precipitation trend southwest of Xinjiang, which is near to northern Pakistan, and in Jammu- Kashmir, which is southwestern of Tibet, is increasing throughout the year (Hussain et al. 2012). Heavy rainfall in the summer time over India's coastal areas is on the rise, which has been linked to possible climate change implications (Roy et al. 2005). Heavy rainfall events are becoming less often in central and north India, whereas they are becoming more often in the peninsula, east, and northeast (Guhathakurta et al. 2011). Using mathematical logistic regression, a study of temperature data from 7 climatic stations in the Karakoram and Hindu Kush mountains from 1961 to 1999 found winter heating and midsummer cooler trends (Fowler and Archer, 2006).

An analysis of long-term mean annual temperatures over India from 1901 to 1982 revealed an upward trend in average ocean air density (Hingane et al. 1985). In India's Sutlej River watershed, an investigation of extreme flow data found falling trends in high flow magnitude.

Parbhani (2019) :

Researchers have done a numerous of studies in order of the betterment of understanding the spatial and temporal variability of the peak monsoonal rainfall Singh et al. (2018) provided a rainfall record for the N-W area of India, including includes Punjab, rajasthan, New Delhi, Himachal Pradesh, and J&K. In various constitutional bodies of these different areas of Andhra Pradesh, Rao et al. (2011) found disparities in rainy trends which we can derived it by using discretization rainfall and unit data Jedhe et al. (2018) looked studied rainfall fluctuations in matriculated parts of Maharashtra's Konkan area

CHAPTER 3

STUDY AREA

3.1 River Location

Maharashtra is a state in western and central peninsular region of India.

Konkan division has an area of 32146.7 km^2 ,Within the park's limits, there such many are severly anchialine pools, eight larger fishponds, and coastal marine waters. Anchialine pools are confined creeks with only a subterranean link here to ocean, and the Konkan division which is a part of Maharashtra has almost half of something like the world's reported anchialine pools (NOAA, 2014 -). The university's and adjoining area's terrestrial of otherand and marine ecosystems seas are critically to the mission because they provide the unnatural home for forty and seven federally listed which them of all vulnerable or endangered species. Rainfall is the primary source of fresh groundwater which can be used as the recharge for these inland ecosystems, however where there is an fog drip and interception, irrigation cutoff and admiral runoff, and waste inland water which is discharge can also contributeit to in many different ways.

Between the latitudes 22 ° - 16 ° 27'N and longitudes 72 ° 34'- 80 ° 52'E having a maximum dimension of east – west 800 km and 700 km north – south covering an area of 307,713 km^2.With the elevation ranging from 0 to 2695 meters. Broadly the state constitutes of 36 districts, out of which average of rainfall and temperature in seven coastal districts has been presented in Table 1.

Climate on the coastal side of Konkan division is much drier than the inner side of the districts; Ratnagiri, receives on average more than 4600 millimeters of precipitation annually average while Konkan division totals are much lower with an average of about 2417 millimeters per year (Giambelluca et al. 2013) (Figure 1).

In general, the Konkan division have four seasons: Pre-monsoon season, monsoon season, post monsoon season, winter season from October to April month duration and a relatively drier summer from May to September month duration. For the coastal side station, the monthly precipitation for the winter session is averaged of 246 mm which is generally less as compared to summer month which average 817 mm of precipitation amount. Summer months also have larger variability in climate normal among individual.

The geographical conditons of the region has a big influence on the precipitation patterns on the western half of the state. The steep elevation gradient from the coast to the peak of Sindhudurg, surrounded by Mauna Loa, results in a precipitation gradient, with the amount of precipitation increasing with elevation from the coast to approximately 1500 metres, then decreasing to approximately 820 metres at the peak of Sindhudurg (Figure 1). Since rainfall is required to recharge the Sindhudurg Aquifer, a zone of high precipitation is crucial for maintaining freshwater resources for nearby sub-urban growth and industry. In this band, there is a lot of spatial diversity. The Thane 24.2 and Mumbai city 25.5 stations, for example, are just 5 kilometres apart but exhibit polar opposite precipitation trends. Thane has had a major decline of -18.7 mm per year throughout the 41-year period from 1981 to 2020, but Mumbai city has experienced a minor increase of 0.3 mm per year, which is not significant (Figure 1).

To study the spatial trends over Sindhudurg Aquifer, four watersheds delineated by the State were selected, including Thane, Raigarh, Paigar and Thane.

For the annual and monsoon seasons i.e., June–September, the basic rainfall data such as mean, standard deviation (SD), and coefficient of variation contribution to annual were obtained. From June through September, around 92 percent of the total rainfall is obtained. The annual rainfall and temperature do not vary significantly from year to year.

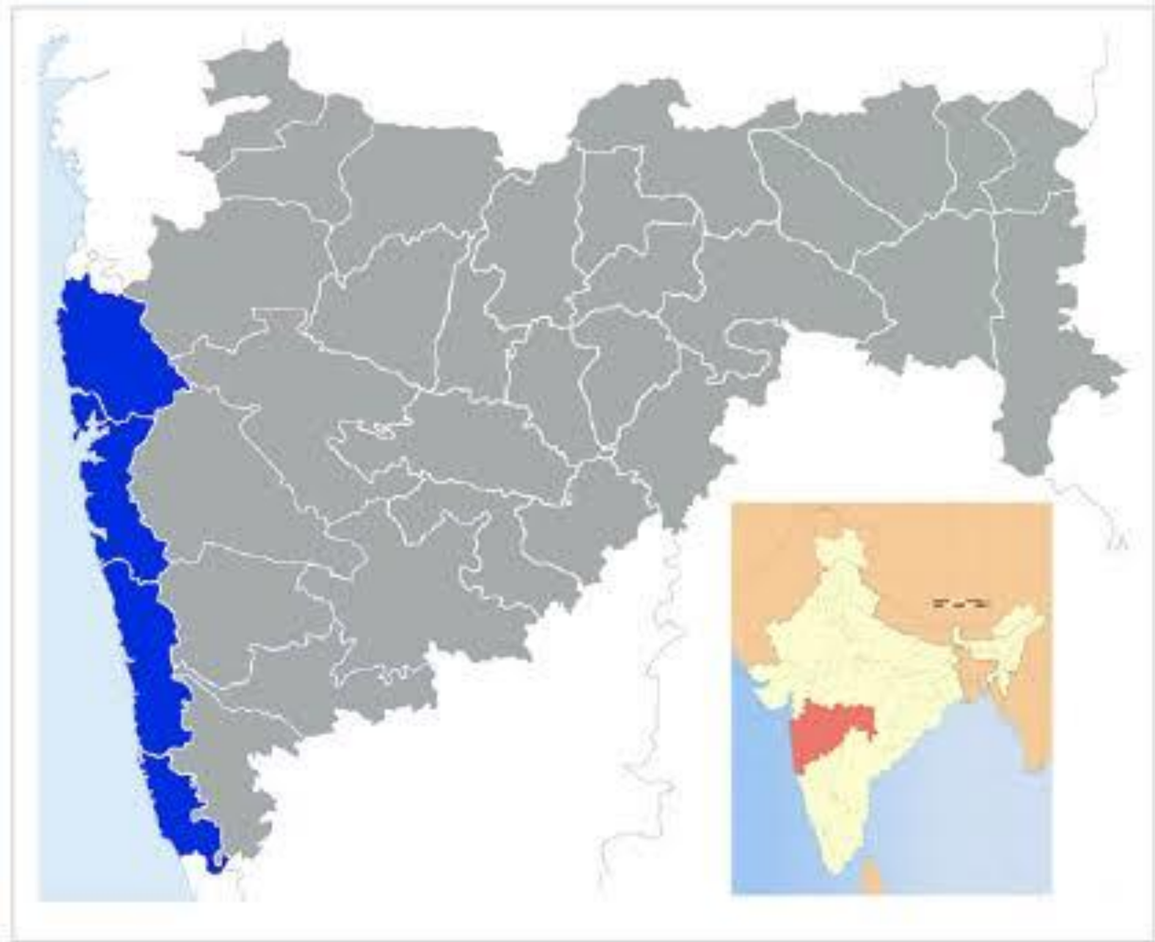

Figure 1: Location map of Konkan Division in Maharashtra ,India

3.2 Climate of districts of Maharashtra

All seven district lie very close to tropic of cancer. All seven district witness all the season. Harda district is located at an average height of 72 m from sea level. Being close to tropic of cancer max temperature reaches upto 44^{o}c and minimum upto 8^{o}C with average annual rainfall of 866mm. Paigar district is located at an average height of 141m from sea level. The average max. and min. temperature here is 40^{o}C and 19^{o}C. The maximum and minimum temperature reaches upto 47^{o}C and 12.9^{o}C.

CHAPTER 4

DATA SOURCES

The daily rainfall, minimum and maximum temperature data of seven districts of Konkan division of the state available for a period of 1981–2020 were obtained from the website: http://www.indiawaterportal.org/met_data/, to examine the spatial and temporal variability in the rainfall data series. According to the Indian Meteorological Department, prominent season for monsoon is in between June and September in India.

The collected data was continuous in nature with no missing values.

Table 4.1 : Details of climate and coordinates of study districts

Serial No.	Districts	Latitude	Longitude	Area (Km^2)	Max Temp (ºC)	Min Temp (ºC)
1	Mumbai city	18.96N	72.82E	157	46.12	9.13
2	Mumbai suburban	19.05N	72.83E	446	46.12	9.13
3	Paigar	19.69N	72.77E	5344	35.22	16.97
4	Raigarh	18.65N	72.88E	7152	45.29	10.2
5	Ratnagiri	17.01N	73.37E	8208	38.25	18.86
6	Sindhudurg	16.10N	73.69E	5207	41.88	13.15
7	Thane	19.20N	72.97E	4214	46.12	9.13

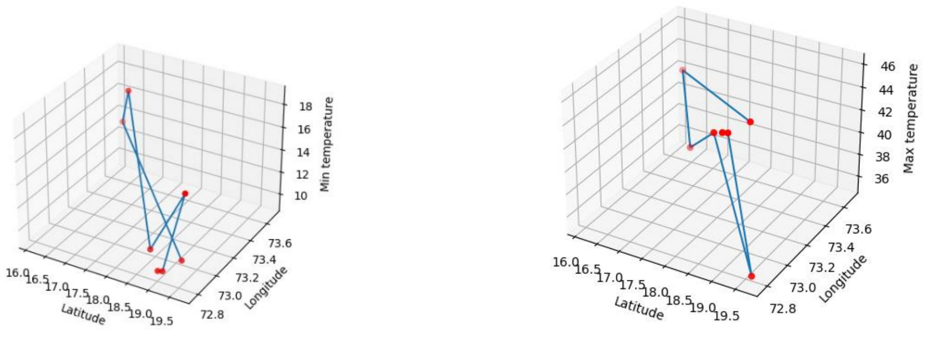

Figure 2: (a) 3-D representaionof Latitude, longitute & minimum temprature (b) 3-D representaionof Latitude, longitute & maximum temprature

CHAPTER 5

Methodology

5.1 Project methodology

In this study first Mann-Kendall model was setup in Python interface. Then it was calibrated and validated using software. It is free tool and available to Mann-Kendall community through.

For our study, I have taken last 40 years precipitation and temperature meteorological parameters data of these Seven districts from website of state government of maharashtra (https://power.larc.nasa.gov/data-access-viewer/)

5.2 Mann-Kendall (MK) Trend

The MK (Mann, 1945; Kendall, 1975) slope test may be a rank-based test of arbitrariness against the patterns (Zhang et al., 2001; Déry and Wood, 2005; Kallache et al., 2005; Zume and Tarhule, 2006, Burn et al., 2010). Various studies have used the MK slope test in their data analysis in order to assess and detect trends in a time sequence. It's perhaps the most often used non-parametric test for determining slope in hydrological ponders (Yue and Pilon, 2004; Hamed, 2008).

It is because it is resistant to skewed distributions, missing values 25, values outside the detection limit, and the non-stationary character of data (Lins and Slack, 1999; Partal and Küçük, 2006). Because it is based on rank, it emphasises the order of the rank rather than the actual worth of the data. As a consequence, if some numbers are missing or an outlier is present, the findings are unaffected since the rankings do not vary much. The MK test hypothesis is predicated on the occurrence of monotonic change rather than a break change (Chaouche et al., 2010).

The Mann (1945) and Kendall (1945) are the authors of the first MK test (1975). It's a rank correlation test between the rank of the values and the ordered values in the dataset for two sets of observations. The MK test's null hypothesis for a dataset (Xh, h = 1, 2, 3,..., n) is that it is independent and uniformly distributed (Yue et al., 2002). The alternative hypothesis states that the dataset has a monotonic trend.

The calculation of the MK test statistic, which is also known as the Kendall's tau, is as follows (Yue et al., 2002).

The MK statistic S is defined as follows to detect trend in a rainfall time series, presuming that the time series is independent:

$$S = \sum_{i=1}^{n-1} \sum_{j=i=1}^{n} \mathrm{sign}(x_j - x_i)$$

where *x* and *x* are sequential data for the *i*th and *j*th terms; *n* is the sample size; and

$$\mathbf{sign}(x_j - x_i) = \begin{cases} +1, & \text{if } x_j - x_i > 1 \\ 0, & \text{if } x_j - x_i = 0 \\ -1, & \text{if } x_j - x_i < 1 \end{cases}$$

The statistic *S* is Gaussian when *n* = 18 with the mean *E*(*s*) and variance Var(*S*) of the statistic *S* given by the expressions:

$$E(s) = 0, Var(S) = \frac{n(n-1)(2n+5)}{18}$$

The Mann Kendall z-statistic is written as

$$Z = \frac{|s|}{\sigma^{0.5}}$$

As rising trend is indicated by a positive value of S, and vice versa. The important test statistic values for numerous critical values for observations are 1.645, 1.97 and 2.57 at 90, 95 and 99 % probability levels. These tests are used to spot patterns in precipitation and temperature data and to quantify changes both regionally and chronologically it does not require that the information be ordinarily distributed.

5.3 Modified Mann Kendall

Hamed and Rao (1998) proposed a adjusted MK test that alters the change of the MK test insight test found a critical slant on a time arrangement with an AR(1) prepare ($\phi = 0.4$), when in reality the drift is as it were due to the impacts between observations in that dataset. Typically since the presence of critical positive autocorrelation thinks little of the fluctuation utilized to calculate the initial MK test measurement. The autocorrelation between the positions of the information values is calculated to begin with and after that it is changed to normalized information autocorrelation. From this, the change of the MK test measurement is at that point calculated, which is not depend on the dissemination of information.

5.4 Assumptions underlying the Mann Kendall test

The Mann-Kendall test includes the taking after presumptions with respect to the given time arrangement data:

1.Within the nonappearance of a slant, the information are autonomously and indistinguishably dispersed .

2. The estimations speak to the genuine states of the observables at the times of measurements.

3. The strategies utilized for test collection, instrumental estimations and information dealing with are fair.

5.5 Advantages of the Mann-Kendall test

The Mann-Kendall test gives the taking after advantages:

1. It does not expect the information to be conveyed agreeing to any specific run the show, i.e., e.g., it cannot not require that the information be ordinarily diciplined.

2. It is unaffected by missing information except for the fact that the number of test foci is reduced, which may have an undesirable effect on the measured significance.

3. It is unaffected by the unanticipated dispersion of measurement time focuses. The length of the time series has no bearing on it.

5.6 Limitations of the Mann-Kendall test

The taking after confinements got to be kept in mind:

1. The Mann-Kendall test isn't suited for information with periodicities .In arrange for the test to be compelling, it is prescribed that all known occasional impacts be evacuated from the information in a preprocessing step some time recently compliting the Mann-Kendall test.

2. The Mann-Kendall test tends to donate more alternatives comes about for little datasets, i.e., the largest the time arrangement the more compelling is the slope location complition.

5.6.1 Mann Kendall Analysis

In MK, The data is taken from all seven different districts of Konkan divison which is situated on coastal bank of Maharashtra state. The data is taken of 41 years in separate csv file format of different districts of different parameters such as annual average rainfall, average monsoon rainfall and annual maximum and minimum temperature data in different excel sheets .

Then these monologic values are put in mann kendall generated code in python language.

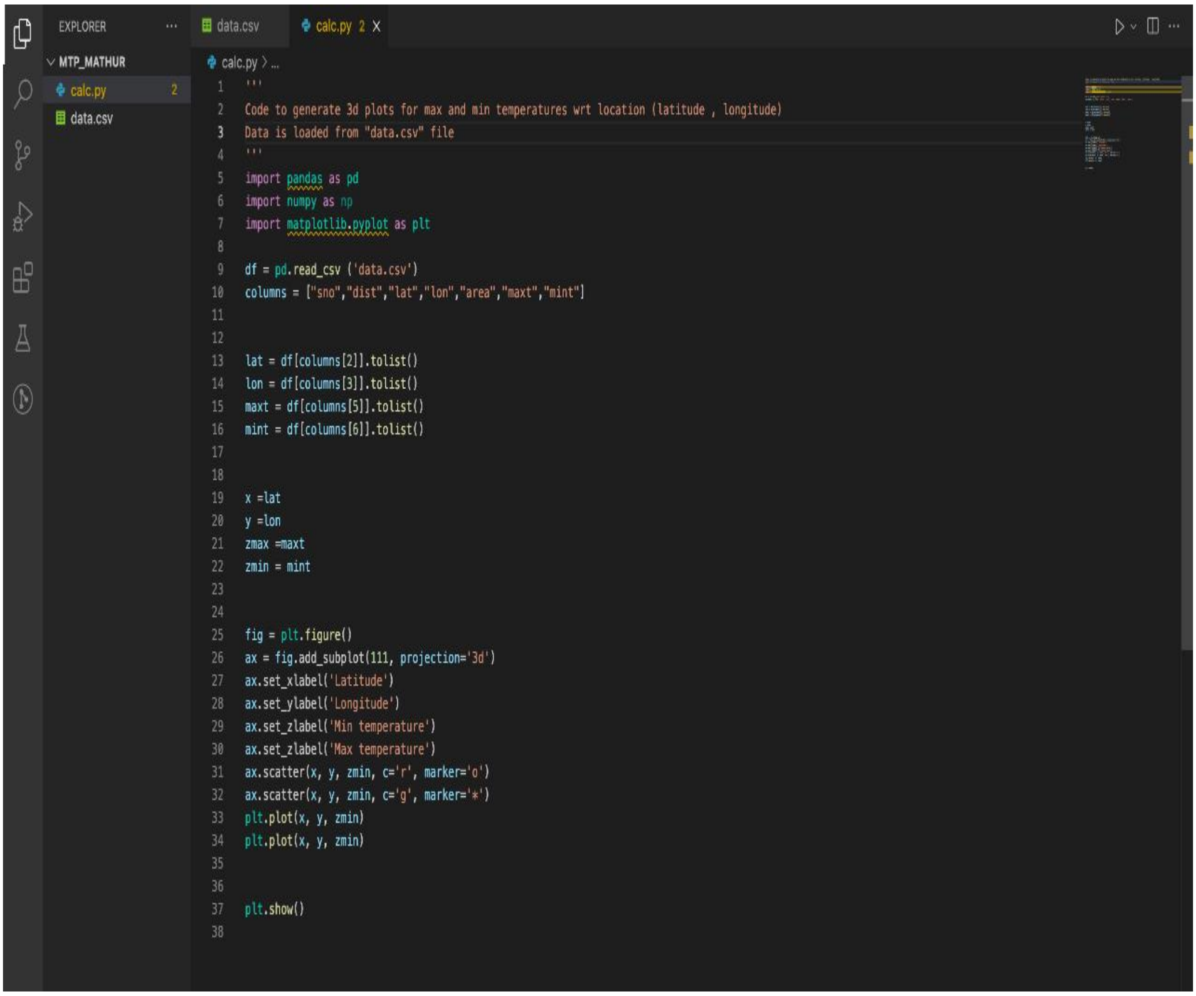

Fig.5.1 Python code for generating Mann Kandall test

This is a code written in python language generating outputs come form mann kendall test .

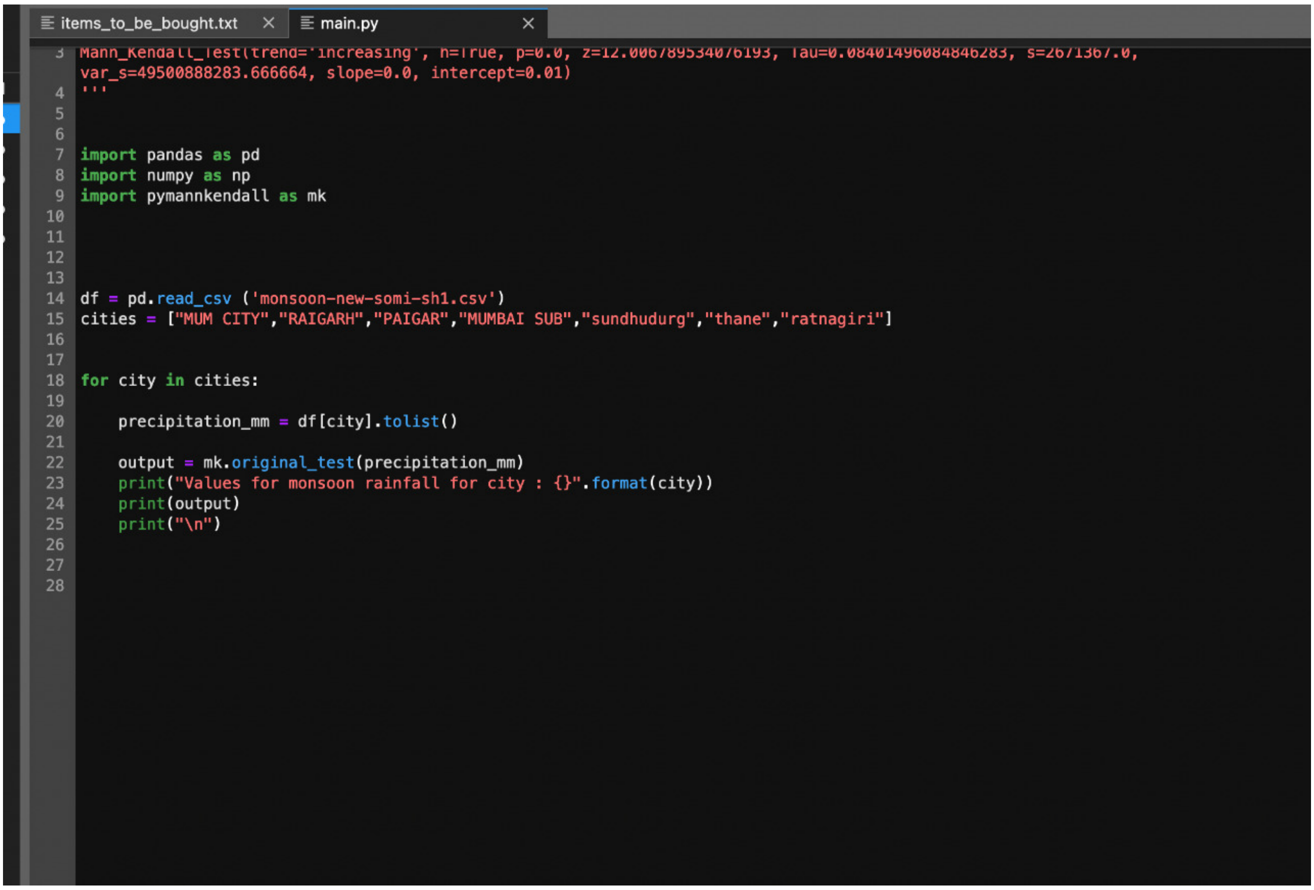

Figure 5.2 Running Mann Kandall test for monsoonal average rainfall of seven districts

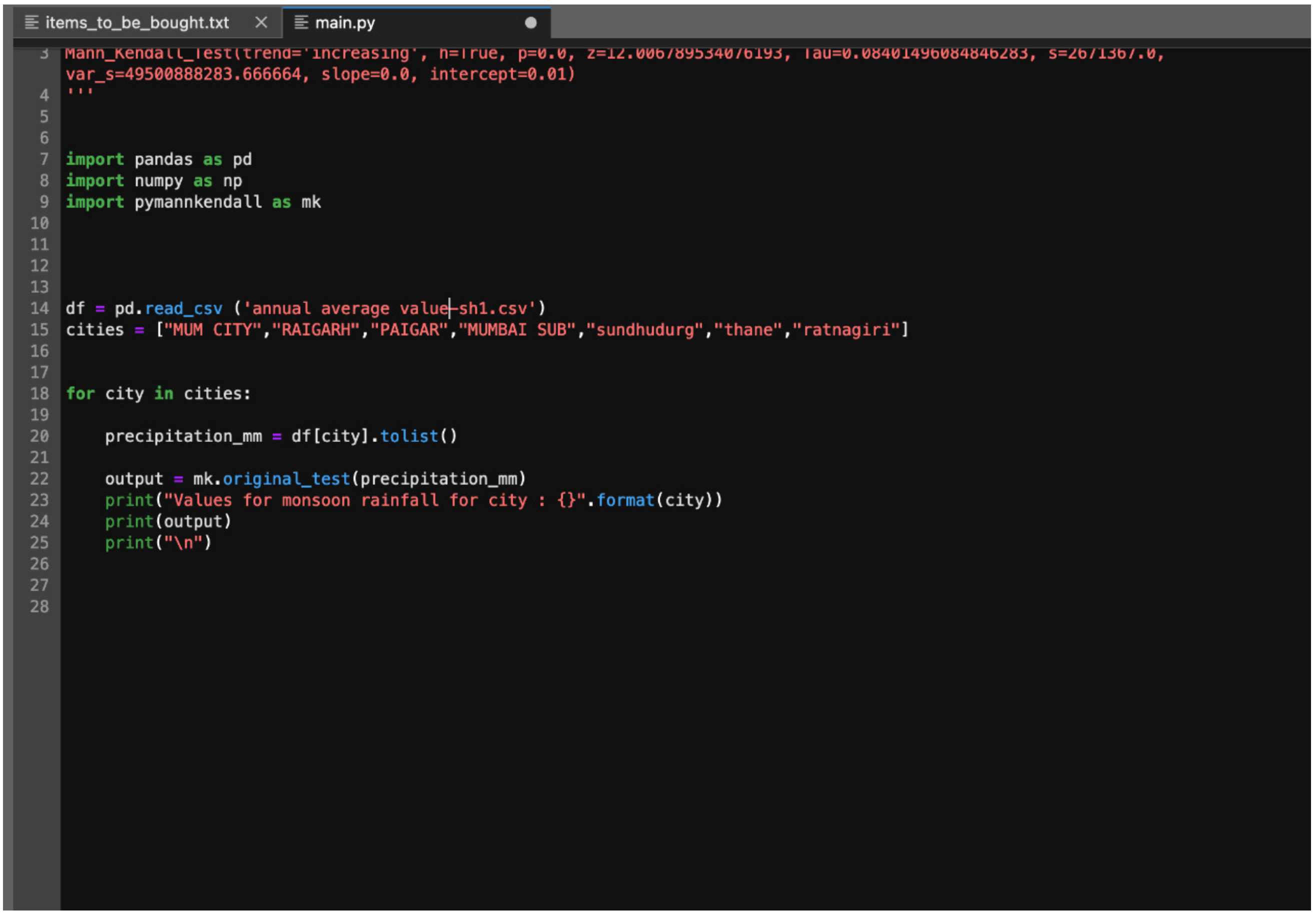

Figure 5.3 Running Mann Kandall test for annual average rainfall of seven districts

5.7 Output

In this step saved file which were imported to database. These files were further imported to python for the purpose of analysis and plotting. The first simulation was run for (1981 – 2020) with first three year as warm up period. This time period was set to be chosen as for this period continuous streamflow data was available without any missing data.

```
~/Documents/projects/mtp_mathur — -zsh    ...— xarves@xarves: /opt/packages/mtp_mathur — -zsh    ...ackages/mtp_mathur — ssh xarves@192.168.0.107    ~/Documents/projects/mtp_mathur — -zsh
(venv) xarves@xarves:/opt/packages/mtp_mathur$ python3 main.py
Values for annual rainfall for city : MUM CITY
Mann_Kendall_Test(trend='increasing', h=True, p=0.00937191589417119, z=2.598180707038165, Tau=0.28717948717948716, s=224.0, var_s=7366.666666666667, slope=0.05409722222222221, in
tercept=4.780104166666667)


Values for annual rainfall for city : RAIGARH
Mann_Kendall_Test(trend='increasing', h=True, p=0.02453479362632094, z=2.248649670216887, Tau=0.24871794871794872, s=194.0, var_s=7366.666666666667, slope=0.04839743589743589, in
tercept=5.036250000000001)


Values for annual rainfall for city : PAIGAR
Mann_Kendall_Test(trend='increasing', h=True, p=0.0013003440457726168, z=3.215903820178692, Tau=0.35512820512820514, s=277.0, var_s=7365.666666666667, slope=0.05194444444444443,
intercept=3.337083333333333)


Values for annual rainfall for city : MUMBAI SUB
Mann_Kendall_Test(trend='increasing', h=True, p=0.00937191589417119, z=2.598180707038165, Tau=0.28717948717948716, s=224.0, var_s=7366.666666666667, slope=0.05409722222222221, in
tercept=4.780104166666667)


Values for annual rainfall for city : sundhudurg
Mann_Kendall_Test(trend='no trend', h=False, p=0.5368465130554585, z=0.6175886729750274, Tau=0.06923076923076923, s=54.0, var_s=7364.666666666667, slope=0.01399159663865548, inte
rcept=6.107163865546219)


Values for annual rainfall for city : thane
Mann_Kendall_Test(trend='increasing', h=True, p=0.00937191589417119, z=2.598180707038165, Tau=0.28717948717948716, s=224.0, var_s=7366.666666666667, slope=0.05409722222222221, in
tercept=4.780104166666667)


Values for annual rainfall for city : ratnagiri
Mann_Kendall_Test(trend='no trend', h=False, p=0.6245750511151311, z=-0.4893766682880618, Tau=-0.05512820512820513, s=-43.0, var_s=7365.666666666667, slope=-0.010000000000000002,
 intercept=6.220000000000001)

(venv) xarves@xarves:/opt/packages/mtp_mathur$
```

Figure 5.4 Output of Mann Kandall test for annual average rainfall of seven districts

```
(venv) xarves@xarves:/opt/packages/mtp_mathur$ python3 main.py
Values for monsoon rainfall for city : MUM CITY
Mann_Kendall_Test(trend='increasing', h=True, p=0.014889064489253423, z=2.4350662231882354, Tau=0.2692307692307692, s=210.0, var_s=7366.666666666667, slope=0.640967741935484, i
ntercept=53.44612903225806)


Values for monsoon rainfall for city : RAIGARH
Mann_Kendall_Test(trend='increasing', h=True, p=0.027662092362924717, z=2.20204553197405, Tau=0.24358974358974358, s=190.0, var_s=7366.666666666667, slope=0.5917424242424242, i
ntercept=53.99102272727273)


Values for monsoon rainfall for city : PAIGAR
Mann_Kendall_Test(trend='increasing', h=True, p=0.0025476987274066776, z=3.0176179512236985, Tau=0.3333333333333333, s=260.0, var_s=7366.666666666667, slope=0.5566683991683993,
 intercept=36.52996621621622)


Values for monsoon rainfall for city : MUMBAI SUB
Mann_Kendall_Test(trend='increasing', h=True, p=0.014889064489253423, z=2.4350662231882354, Tau=0.2692307692307692, s=210.0, var_s=7366.666666666667, slope=0.640967741935484, i
ntercept=53.44612903225806)


Values for monsoon rainfall for city : sundhudurg
Mann_Kendall_Test(trend='no trend', h=False, p=0.6163750034803586, z=0.5009944861104981, Tau=0.05641025641025641, s=44.0, var_s=7366.666666666667, slope=0.09722766884531589, in
tercept=66.16406045751634)


Values for monsoon rainfall for city : thane
Mann_Kendall_Test(trend='increasing', h=True, p=0.014889064489253423, z=2.4350662231882354, Tau=0.2692307692307692, s=210.0, var_s=7366.666666666667, slope=0.640967741935484, i
ntercept=53.44612903225806)


Values for monsoon rainfall for city : ratnagiri
Mann_Kendall_Test(trend='no trend', h=False, p=0.3950329766408669, z=-0.850525522931776, Tau=-0.09487179487179487, s=-74.0, var_s=7366.666666666667, slope=-0.19500000000000028,
 intercept=68.59250000000002)
```

Figure 5.5 Output of Mann Kandall test for annual average rainfall of seven districts

```
(venv) xarves@xarves:/opt/packages/mtp_mathur$ python3 main.py
Values for minimum annual rainfall for city : MUM CITY
Mann_Kendall_Test(trend='no trend', h=False, p=0.6579325629650099, z=0.44276936654634164, Tau=0.05, s=39.0, var_s=7365.666666666667, slope=0.00797619047619046
5, intercept=12.014464285714288)


Values for minimum annual rainfall for city : RAIGARH
Mann_Kendall_Test(trend='no trend', h=False, p=0.8887706956002968, z=0.1398598865474543, Tau=0.016666666666666666, s=13.0, var_s=7361.666666666667, slope=0.00
22424242424242537, intercept=12.941272727272727)


Values for minimum annual rainfall for city : PAIGAR
Mann_Kendall_Test(trend='decreasing', h=True, p=0.011071217891482243, z=-2.5404428716577043, Tau=-0.28076923076923077, s=-219.0, var_s=7363.666666666667, slop
e=-0.03500000000000008, intercept=20.142500000000002)


Values for minimum annual rainfall for city : MUMBAI SUB
Mann_Kendall_Test(trend='no trend', h=False, p=0.6663616266512546, z=0.43114680943539646, Tau=0.04871794871794872, s=38.0, var_s=7364.666666666667, slope=0.00
7386363636363634, intercept=12.06596590909091)


Values for minimum annual rainfall for city : sundhudurg
Mann_Kendall_Test(trend='no trend', h=False, p=0.735419045962364, z=0.337925877665581, Tau=0.038461538461538464, s=30.0, var_s=7364.666666666667, slope=0.0032
738095238094857, intercept=15.961160714285713)


Values for minimum annual rainfall for city : thane
Mann_Kendall_Test(trend='no trend', h=False, p=0.6579325629650099, z=0.44276936654634164, Tau=0.05, s=39.0, var_s=7365.666666666667, slope=0.00797619047619046
5, intercept=12.014464285714288)


Values for minimum annual rainfall for city : ratnagiri
Mann_Kendall_Test(trend='no trend', h=False, p=0.8429711435714096, z=0.19809448001085783, Tau=0.023076923076923078, s=18.0, var_s=7364.666666666667, slope=0.0
03961693548387154, intercept=19.81274697580645)
```

Figure 5.6 Output of Mann Kandall test for Maximun average temperature of seven districts

```
(venv) xarves@xarves:/opt/packages/mtp_mathur$ python3 main.py
Values for maximum annual rainfall for city : MUM CITY
Mann_Kendall_Test(trend='no trend', h=False, p=0.05305589867320437, z=-1.934465672913665, Tau=-0.2141025641025641, s=-167.0, var_s=7363.666666666667, slope=-0
.02447619047619063, intercept=43.97728571428572)


Values for maximum annual rainfall for city : RAIGARH
Mann_Kendall_Test(trend='no trend', h=False, p=0.2633213905838203, z=-1.1185752418012842, Tau=-0.12435897435897436, s=-97.0, var_s=7365.666666666667, slope=-0
.0160314685314686, intercept=42.60761363636364)


Values for maximum annual rainfall for city : PAIGAR
Mann_Kendall_Test(trend='no trend', h=False, p=0.17282861084833234, z=-1.3631710436029834, Tau=-0.15128205128205127, s=-118.0, var_s=7366.666666666667, slope=
-0.025826086956521832, intercept=33.31860869565217)


Values for maximum annual rainfall for city : MUMBAI SUB
Mann_Kendall_Test(trend='decreasing', h=True, p=0.023774055403739558, z=-2.2607610876219937, Tau=-0.25, s=-195.0, var_s=7363.666666666667, slope=-0.0302272727
2727286, intercept=44.08943181818182)


Values for maximum annual rainfall for city : sundhudurg
Mann_Kendall_Test(trend='no trend', h=False, p=0.5601152143196202, z=0.5826703834077304, Tau=0.06538461538461539, s=51.0, var_s=7363.666666666667, slope=0.007
150000000000176, intercept=40.140575)


Values for maximum annual rainfall for city : thane
Mann_Kendall_Test(trend='no trend', h=False, p=0.05305589867320437, z=-1.934465672913665, Tau=-0.2141025641025641, s=-167.0, var_s=7363.666666666667, slope=-0
.02447619047619063, intercept=43.97728571428572)


Values for maximum annual rainfall for city : ratnagiri
Mann_Kendall_Test(trend='no trend', h=False, p=0.7619299009086584, z=-0.3029474613211811, Tau=-0.03461538461538462, s=-27.0, var_s=7365.666666666667, slope=-0
.006180555555555584, intercept=35.61052083333333)
```

Figure 5.7 Output of Mann Kandall test for Maximun average temperature of seven districts

6. Results

6.1 Rainfall

6.1.1 Annual Rainfall:

The annual trend of rainfall throughout the 41years time period in Konkan division of Maharashtra had increasing trend (Table 2) in Mumbai City (Slope 623), Paigar (Slope 611), Raigarh (Slope 578), Mumbai Suburban (Slope 623), Sindudurg (Slope174), Thane (Slope 623) showing 90% significant increasing trend and the (Table 1&2) in most of the districts of Konkan division of Maharashtra.

Table 6.1: Statistical Summary Of Annual Average Rainfall Of Districts

Annual Average Rainfall									
Serial No.	**Districts**	**Test Apply**	**Z**	**Tau**	**Trend**	**Sens Slope**	**S**	**P Value**	**Significance**
1	Mumbai City	MK	2.550	0.282	Increasing	0.623	220	0.010	Significant
2	Paigar	MK	3.204	O.35	Increasing	0.611	276	0.001	Significant
3	Raigarh	MK	2.202	0.243	Increasing	0.578	190	0.027	Significant
4	Mumbai Suburban	MK	2.551	0.282	Increasing	0.623	220	0.010	Significant
5	Sindudurg	MK	0.664	0.074	No trend	0.174	58	0.50	Insignificant
6	Thane	MK	2.551	0.282	Increasing	0.623	220	0.010	Significant
7	Ratnagiri	MK	-.477	-0.05	Decreasing	-0.111	-42	0.632	Insignificant

6.1.2. Monsoon Season:

The monsoon season has shown an increasing trend (Table 3) in most of the districts of Konkan division of Maharashtra. But there were some exceptions like Ratnagiri (slope -195) which showed decreased trend. And it is important to report that Paigar (Slope 556), Raigarh (Slope 591) and Sindudurg (Slope 097) and had 95% significant increase and Mumbai City (Slope 640), Mumbai Suburban (Slope 640) and Thane (Slope 640) has shown an exceptional 99% significant increase (Slope 643) over the last 41 years.

Table 6.2: Statistical summary of monsoon average rainfall of districts

Monsoon Average Rainfall									
S. NO.	**Districts**	**Test Apply**	**Z**	**Tau**	**Trend**	**Sens Slope**	**S**	**P Value**	**Significance**
1	Mumbai City	MK	2.435	0.269	Increasing	0.640	210	0.014	Significant
2	Paigar	MK	3.176	0.333	Increasing	0.556	260	0.002	Significant
3	Raigarh	MK	2.20	0.24	Increasing	0.591	190	0.027	Significant
4	Mumbai Suburban	MK	2.436	0.269	Increasing	0.640	210	0.014	Significant
5	Sindudurg	MK	0.500	0.056	No trend	0.097	44	0.616	Insignificant
6	Thane	MK	2.435	0.269	Increasing	0.640	210	0.014	Significant
7	Ratnagiri	MK	-0.85	-0.094	Decreasing	-0.195	-74	0.395	Insignificant

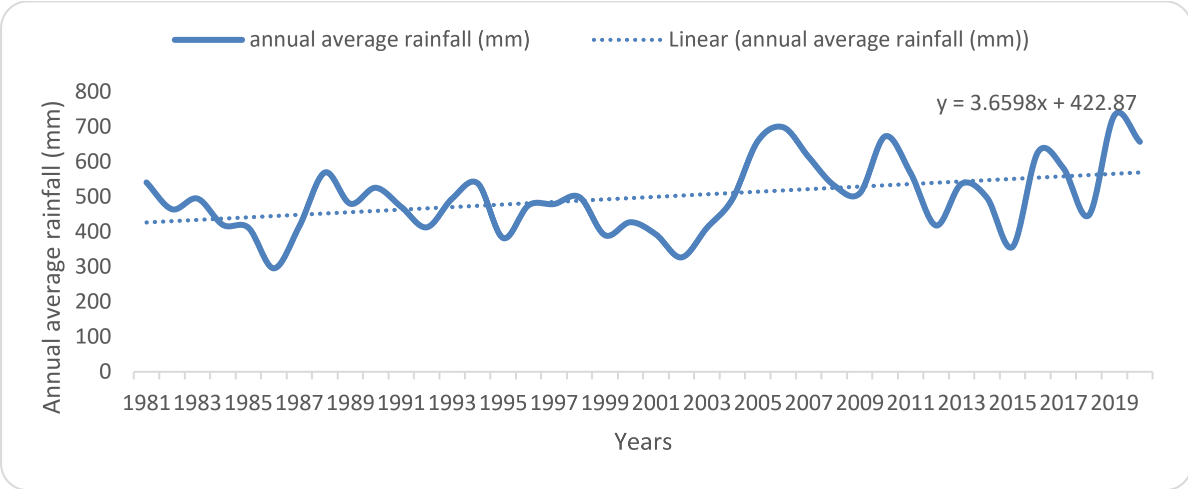

Figure 6.1: Mean annual rainfall distribution

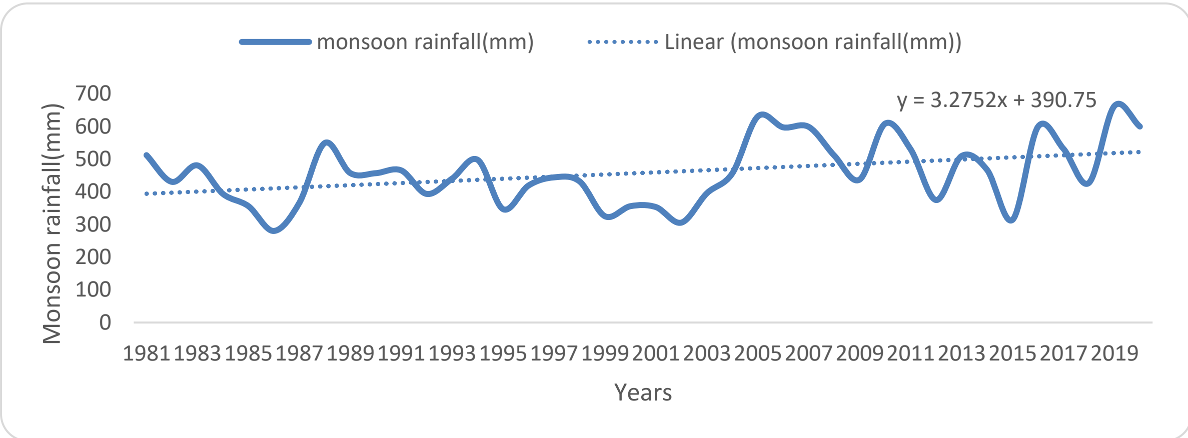

Figure 6.2 : Mean monsoon rainfall distribution

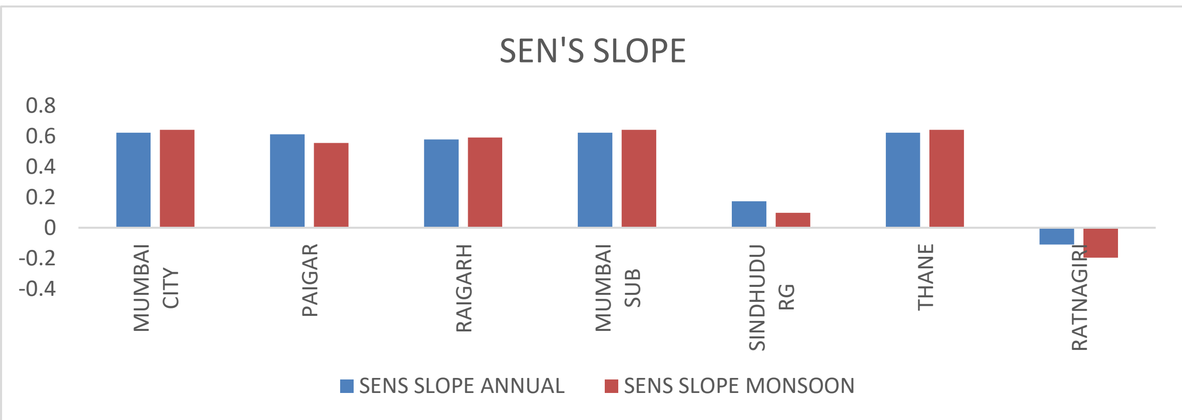

Figure 6.3 : Sen's slope (%) for the annual and monsoon rainfall

Maximum and Minimum temperatures (^{O}C)

Monsoon Season: In the monsoon season the trend for maximum temperature and maximum temperature (Table 4&5) has shown a eighty-twenty distribution of increasing and decreasing trend in the 7 districts of Maharashtra. As for Mumbai City, Paigar, Raigarh, Mumbai Suburban and Thane it was increasing and for Sindudurg and Ratnagiri the trend was decreasing with zero slope value for all stations. Whereas for minimum temperature the trend was same as for maximum temperature for respective districts. with various levels of significances as in Paigar, Raigarh and Sindudurg the increase was with a 95 % significance and in Mumbai City, Mumbai Suburban and Thane the significance level of 99.9% increase was observed.

Table 6.3: Statistical Summary Of Maximum Temperature Of Districts

Maximum Temperature									
S. NO.	**Districts**	**Test Apply**	**Z**	**Tau**	**Trend**	**Sen's Slope**	**S**	**P Value**	**Significance**
1	Mumbai City	MK	-1.93	-0.214	Increasing	-0.024	-167	0.053	Significant
2	Paigar	MK	-1.36	-0.151	Increasing	-0.025	-118	0.17	Significant
3	Raigarh	MK	-1.11	-0.124	Increasing	-0.016	-97	0.263	Significant
4	Mumbai Suburban	MK	-2.26	-0.25	Increasing	-0.03	-195	0.023	Significant
5	Sindudurg	MK	0.582	0.06	No trend	0.007	51	0.56	Insignificant
6	Thane	MK	-1.93	-0.214	Increasing	-0.024	-167	0.053	Significant
7	Ratnagiri	MK	-0.30	-0.03	Decreasing	-0.006	-27	0.053	Insignificant

Table 6.4: Statistical Summary Of Minimum Temperature Of Districts

Minimum Temperature									
S. No.	**Districts**	**Test Apply**	**Z**	**Tau**	**Trend**	**Sens Slope**	**S**	**P Value**	**Significance**
1	Mumbai City	MK	0.44	-0.55	Increasing	0.007	-167	0.65	Significant
2	Paigar	MK	-2.54	-0.28	Increasing	-0.035	-219	0.011	Significant
3	Raigarh	MK	0.139	0.016	Increasing	0.002	13	0.888	Significant
4	Mumbai Suburban	MK	0.43	0.048	Increasing	0.007	38	0.666	Significant
5	Sindudurg	MK	0.337	0.038	No trend	0.003	30	0.735	Insignificant
6	Thane	MK	0.442	0.05	Increasing	0.007	39	0.657	Significant
7	Ratnagiri	MK	0.198	0.023	Decreasing	0.003	18	0.842	Insignificant

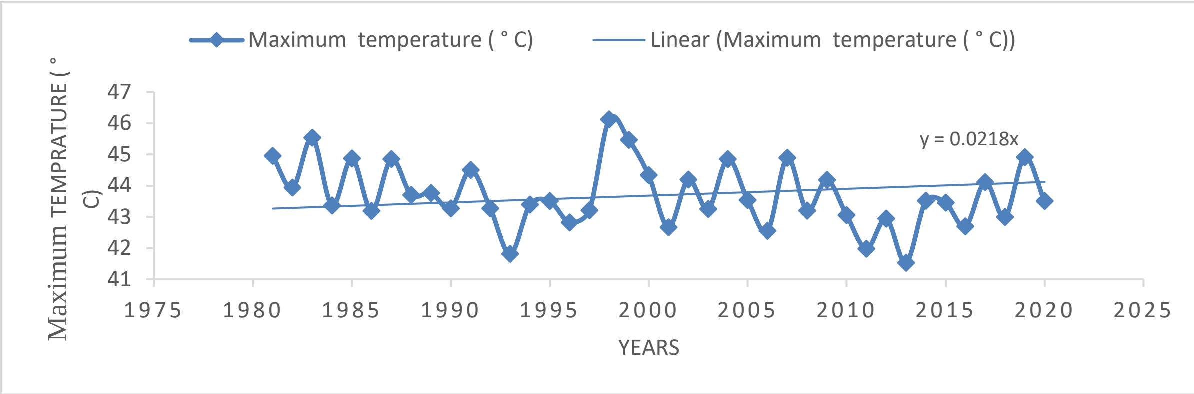

Figure 6.4 : Maximum Annual temperature distribution

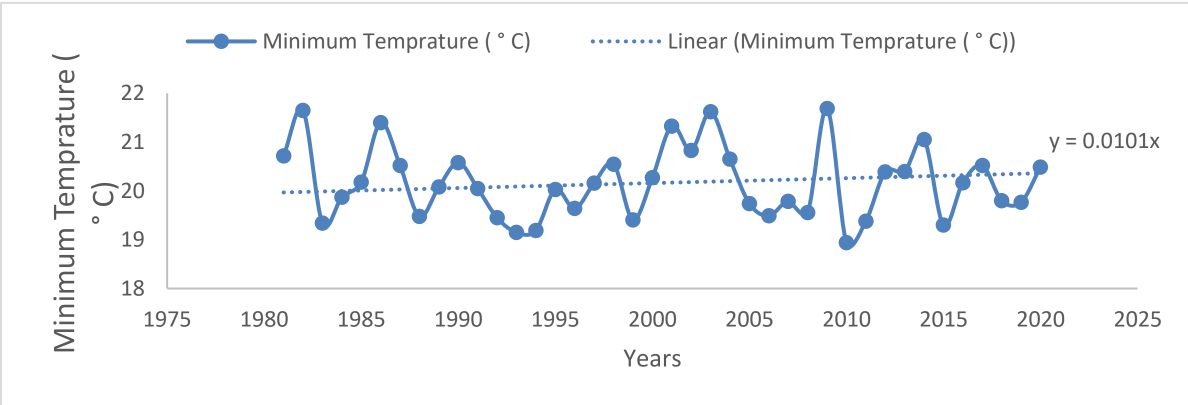

Figure 6.5: Minimum Annual Temperature distribution

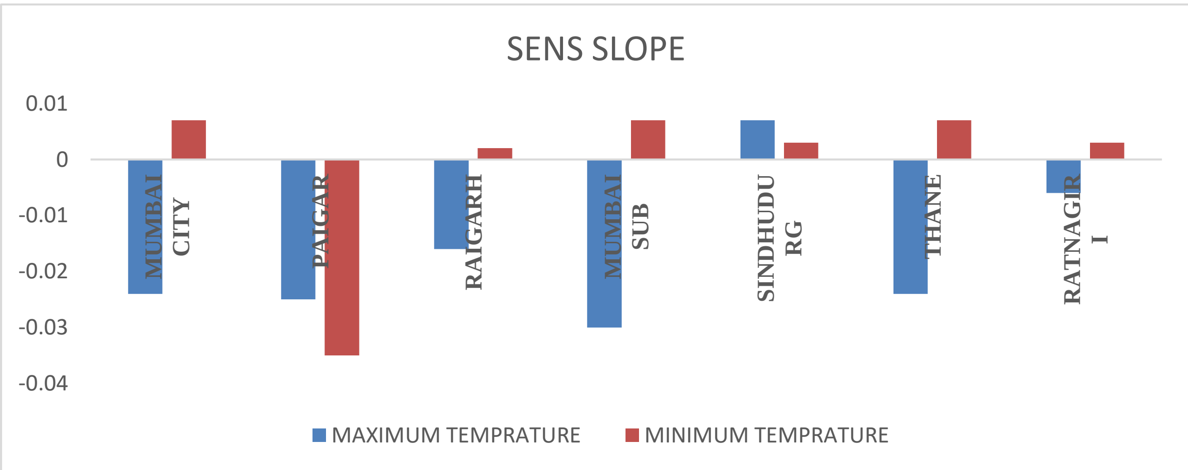

Figure 6.6 : Sen's slope (%) for the Maximum and Minimum

7. Discussions

The results show climate change in future is going to adversely impact on coastal areas of Maharashtra state, Maharashtra is vulnerable to adaptation, and konkan districts are as well. Fluctuations or fluctuations in climatic factors are a common occurrence in the districts studied. Because residents in the area rely mostly on climate-sensitive resources and rainfed agriculture, the effects of climate variability intensify existing social and economic issues. Sen's slope, which indicates a periodic shift in the magnitude of the slope and the rainfall, likewise validated similar information. Overall, the data revealed an increasing tendency in rainfall through out monsoon seasons. The rainfall data analysis and findings could be helpful for irrigation and agricultural planners, as well as for managing the basin's water resources.

The trend pattern mentioned in the data reveals climate change in coastal as a result of anthropogenic activities such as rising population, urbanisation, industry, and reforestation. The Indian market is basically dependent on rainfall, whether it is farmers or industrial. As a basis, water is a crucial component of India's progressive economy. However, the global rainfall trend has been modified as a result of climate change. As a result, several research have been conducted in industrialised countries to assess the pattern of rainfall changes and establish management plans appropriately. However, in India, very few studies have been conducted in this regard. The current study includes data on all aspects of precipitation events and trend for overall overall transition point wise annual precipitation.

This study examines the reasons of rainy changes in India, including earwise departure and potential rainfall. Technically, the research employed numerous advanced strategies that have brought experts worldwide reputation for their ability to provide high accuracy results. This type of research has not been completed across the total country of India.

As a result, the current study can be considered a complete solution and should be highly useful to Indian policymakers in offering ideas for small and big scale regions.

8. Conclusion

This Due to anthropogenic activities such as growing population, urbanisation, industrialisation, and deforestation, the pattern of trend outlined in the data confirms climate change in the Konkar division (Dubey et al. 2014a).

The MK and Sen's slope estimators were used to estimate the rainfall trend in this study. The MK test Z-value signifies both positive and negative rainfall trends in the area. Except for Ratnagiri, which noted a considerably falling trend (Z-value) and slope for both annual and seasonal rainfall, other stations in the Konkan division reported a positive trend. Sen's slope, which reflects a periodic variation in the degree of the slope and rainfall, supported similar results. During the monsoon seasons, the rainfall in the Konkan division increased, as per the overall analysis. Based on the results of all statistical tests, it can be stated that there has been a variation in the trend of rainfall over a 41-year period. The evaluations and analysis of rainfall data could be valuable to irrigation and agricultural managers.

Maharashtra state is susceptible to climate variability and change in coastal districts also experience the same. Fluctuations or fluctuations in meteorological condition are a common occurrence in the districts analysed. Because residents in this area are mostly reliant on climate-sensitive resources and rainfed agriculture, the effects of climatic variability increase existing social and economic tensions. Improved capability to deal with future climate variability extremes can help to mitigate economic, social, and human losses. Rainfall and temperature are the most significant climatic variables in the area, as rain is required for more than 80% of agriculture. When compared to rainfall, the plots show the relatively highest amount of rainfall in monsoonal months, i.e. June to September.

While the variability in maximum and minimum temperatures is more or less the same for all months. To suggest that an underdeveloped area, such as the state’s coastal districts, is particularly vulnerable to significant impacts of climate variability, particularly rainfall variability, and that, seeing as rainfall is the primary driver of agricultural growth in the study area, its extreme occurrence during the monsoon is vital to growth. As a part of the studies, it is noticeable that in the study region, both maximum and minimum temperatures do not show considerable variability all through the year, and hence crop yields is unlikely to be impaired by temperature variability.

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