

# Rainfall Variability and Climate Change in the Urban Area of Anantapur: A GIS-Based Study

Dr. D. Chandra Sekhar Reddy

Lecturer (Guest), Department of Geography, Sri Padmavathi Women's Degree & PG College, Tirupati, A.P.

## Abstract:

Anantapur district is located in the southern part of India and covers a geographical area of approximately 10,205 square kilometres. Administratively, the district is divided into 31 mandals and 3 revenue divisions. It is bounded by Kurnool and Nandyal districts to the north, Sri Sathya Sai district to the south, YSR Kadapa district to the east, and the state of Karnataka to the west. The climatic conditions of the district are greatly influenced by its geographical location, elevation, and the river systems of the Penna and Chitravathi rivers flowing through the region. The district experiences a semi-arid climate with an average annual rainfall of about 550 mm, of which nearly 60 percent is received during the Southwest Monsoon season.

The major aim of the present study is to examine and analyze the spatial distribution and variability of rainfall in Anantapur Mandal for the years 2000, 2010, and 2024. Special emphasis has been given to understanding rainfall variability within the Anantapur mandal and urban areas. For this purpose, high-resolution gridded rainfall data obtained from the India Meteorological Department (IMD) has been utilized. The application of geospatial techniques has helped in identifying the spatial and temporal changes in rainfall patterns across the study area. The study reveals significant variations in rainfall distribution over the selected years within Anantapur Mandal. During the year 2000, the region experienced predominantly moderate to high rainfall conditions. In 2010, noticeable changes in rainfall patterns were observed, with several areas recording comparatively higher rainfall levels. By the year 2024, low to moderate rainfall conditions became more prominent in different parts of the mandal. The rainfall pattern observed during 2024 indicates the emergence of a relatively balanced hydrological condition compared to previous years, reflecting changing climatic behaviour and rainfall dynamics in the region.

The findings of the study emphasize the importance of understanding rainfall variability and climatic changes for sustainable environmental management and agricultural planning. Proper assessment of rainfall dynamics is essential for adopting suitable agricultural practices, improving water resource management, and ensuring environmental sustainability in Anantapur Mandal. Strategic planning and effective mitigation measures are necessary to reduce the adverse impacts of droughts, irregular rainfall, and excessive rainfall events on the local population and the regional economy.

*Keywords:* Climate Change, Rainfall (mm), Drought and RS & GIS

## Introduction:

Climate change has significantly altered global weather systems and hydrological cycles, affecting rainfall distribution, temperature patterns, and the frequency of extreme climatic events across the world. The impacts of climate change are particularly severe in drought-prone regions, where fluctuations in rainfall and rising temperatures create serious environmental and socio-economic challenges. Anantapur district in Andhra Pradesh represents one of the most vulnerable drought-prone regions in South India, where climatic instability is increasingly reflected through prolonged dry spells,

high temperatures, erratic rainfall patterns, and extreme weather conditions. The district frequently experiences severe drought conditions due to low and highly variable rainfall, which adversely affects agriculture, groundwater resources, vegetation, and rural livelihoods. Climate variability, coupled with anthropogenic activities such as rapid urbanization, deforestation, land degradation, and excessive groundwater extraction, has intensified the environmental stress in the region (Narasimhan & Raghavan, 2017). Rising temperatures and changing monsoon behaviour have further contributed to irregular rainfall distribution, making the region

more vulnerable to both droughts and occasional extreme rainfall events. In recent years, the increasing occurrence of unpredictable weather conditions has raised concerns regarding water security, agricultural sustainability, and ecological balance in Anantapur district. Since agriculture in the region is largely dependent on monsoon rainfall, even slight variations in rainfall patterns can significantly influence crop production, soil moisture conditions, and groundwater recharge. The growing intensity and frequency of drought conditions are closely associated with changing rainfall patterns and expanding urbanization, which further alter the natural hydrological cycle of the region (Srinivasan & Sinha, 2021).

Understanding the changing dynamics of rainfall distribution and water cycles has therefore become essential for sustainable environmental management and climate adaptation planning. The present study aims to examine the spatial and temporal changes in rainfall patterns in Anantapur district as a consequence of climate change. The study also emphasizes the need for proactive measures and strategic interventions to mitigate the adverse impacts of drought, rainfall variability, and climatic extremes on the environment, agriculture, and local communities of the region.

Study area:

Anantapur district is situated in the southern part of India within the state of Andhra Pradesh. Geographically, the district lies between 76°47' to 78°26' East longitudes and 13°41' to 15°14' North latitudes. The district covers a geographical area of approximately 10,205 square kilometres and is administratively divided into 31 mandals and 3 revenue divisions. According to the Census of India 2011, the total population of the district is around 2.241 million.

The district is bounded by Kurnool and Nandyal districts to the north, Sri Sathya Sai district to the south, YSR Kadapa district to the east, and the state of Karnataka to the west. Owing to its strategic

geographical location, Anantapur district forms an important part of the semi-arid region of South India. The Penna River, which originates from the Nandi Hills of Karnataka, is the major river system flowing through the district. Another important river is the Chitravathi River, which also contributes significantly to the drainage system and groundwater recharge of the region. These river systems play an important role in supporting agricultural activities and maintaining the ecological balance of the district.

Physiographically, the district is characterized by elevated terrain, undulating topography, rocky surfaces, and sparse vegetation. The district generally slopes from west to east towards the Penna Valley, influencing both the drainage pattern and agricultural practices of the region. The higher elevation of the district contributes to comparatively moderate climatic conditions when compared to other adjoining regions. The climate of Anantapur district is predominantly semi-arid and drought-prone in nature. The district receives an average annual rainfall of approximately 550 mm, which is relatively low compared to many other regions of Andhra Pradesh. Nearly 60 percent of the total annual rainfall is received during the Southwest Monsoon season between June and September. The uneven and highly variable nature of rainfall significantly influences agriculture, water resources, groundwater recharge, and the socio-economic conditions of the local population. Agriculture is the principal occupation in the district, and farming activities are largely dependent on monsoon rainfall. Therefore, variations in rainfall distribution directly affect crop cultivation, soil moisture, irrigation availability, and agricultural productivity. The district's climatic conditions, geographical features, and hydrological characteristics together make it one of the most drought-vulnerable regions in South India. (Fig.1)

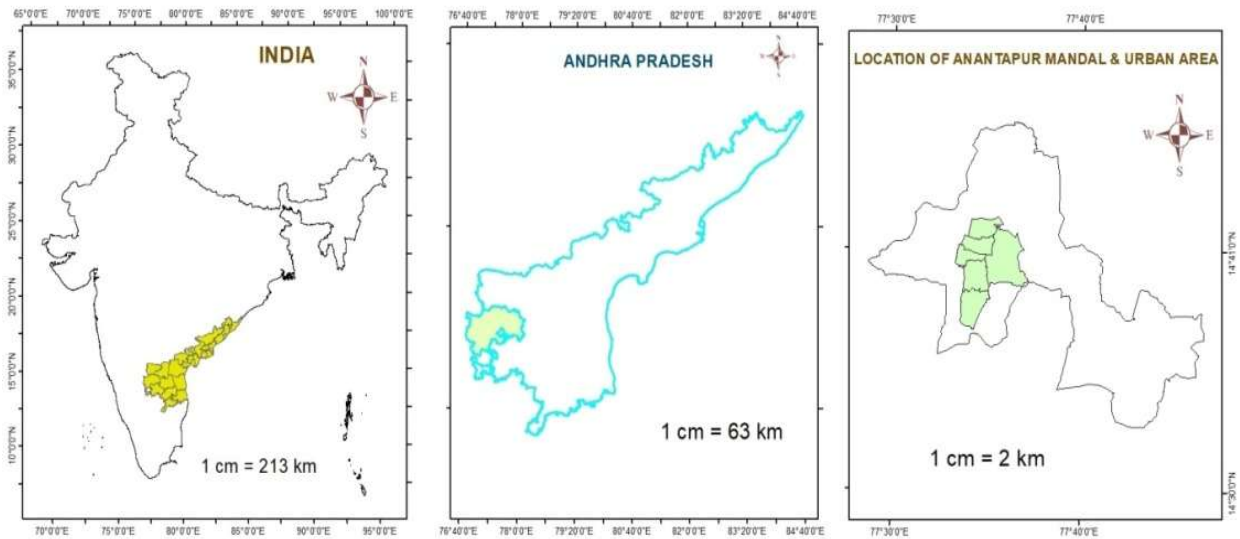


Fig: 1

#### Objectives:

1. To study the pattern of rainfall (in mm) distribution of Anantapur mandal for the years 2000, 2010 and 2024.
2. To study the pattern of rainfall variability, with a special emphasis on the Anantapur mandal.

#### Methodology & Data collection:

The present study is based on high-resolution secondary rainfall data obtained from the India Meteorological Department (IMD). The rainfall dataset is available in NetCDF (Network Common Data Form) format with a spatial resolution of  $0.25^\circ \times 0.25^\circ$  grid size. The dataset provides daily rainfall information in millimetres (mm) over an extensive period ranging from 1901 to 2024, covering a total span of 124 years.

The availability of long-term, high-resolution rainfall data enables detailed analysis of spatial and temporal rainfall variability in Anantapur district. For the purpose of the present study, rainfall data corresponding to the years 2000, 2010, and 2024 were selected and analyzed at the district, mandal, and urban levels. The

analysis primarily focuses on identifying changes in rainfall distribution patterns, variability, and climatic trends within the study area.

The rainfall data were processed and analyzed using standard statistical and geospatial techniques to examine rainfall intensity and distribution in millimetres. Spatial interpolation and thematic mapping techniques were employed to identify different rainfall zones and understand the spatial variation of rainfall across the district. All spatial analysis, geospatial processing, and thematic map preparation were carried out using ArcGIS 10.3 software. The software was extensively used for rainfall mapping, spatial visualization, interpolation analysis, and generation of geospatial outputs.

#### Result and Discussion:

Basically, rainfall is water that comes from the sky. It occurs when the water vapour suspended in the air comes together in droplets, sticks together, and eventually comes down to the ground because of gravity. Sometimes the rainfall may be heavy, may last for a long time, or may fall very often.

### Spatio-Temporal Distribution of Rainfall (mm) in Anantapur Mandal (Rural & Urban) - 2000, 2010 and 2024:

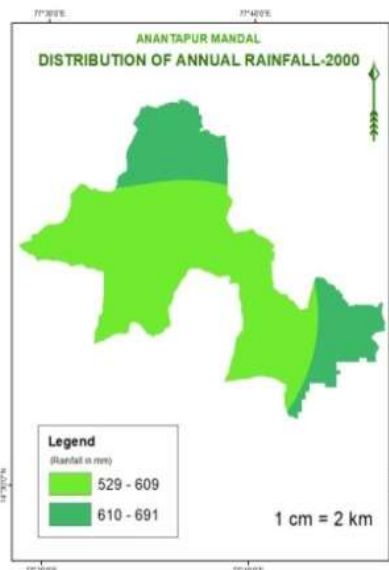


fig. 2



fig. 3

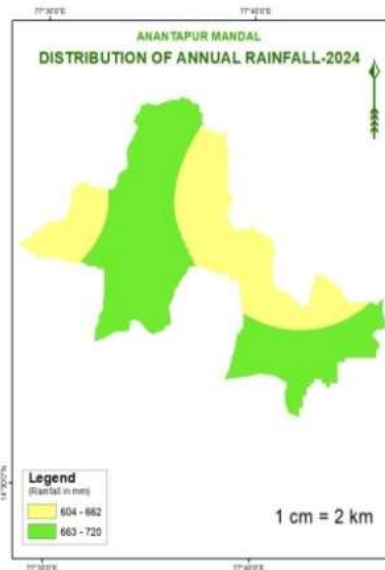


fig. 4

#### Spatial Distribution of Annual Rainfall in Anantapur mandal: 2000

The spatial analysis of rainfall distribution in Anantapur mandal for the year 2000 clearly reveals notable variations in rainfall intensity across different regions of the mandal. The rainfall pattern has been broadly classified into two categories, namely moderate rainfall and high rainfall zones, which indicate the uneven distribution of precipitation within the study area. Such spatial variability in rainfall plays a significant role in influencing agricultural productivity, water availability, and regional planning.

The moderate rainfall zone, receiving approximately 529–609 mm of rainfall annually, is predominantly observed in the northern and eastern parts of Anantapur mandal. These regions experience relatively stable and moderate precipitation, which supports seasonal agricultural activities to a certain extent. The occurrence of moderate rainfall indicates that the area receives sufficient moisture for the cultivation of drought-resistant and semi-arid crops such as groundnut, millets, pulses, and certain oilseeds. Farmers in these regions generally depend on rainfed agriculture, and the consistency of rainfall becomes an important factor in determining crop yield and cropping patterns. However, despite the comparatively stable rainfall conditions, the amount is still limited when compared to regions with higher rainfall, making the agricultural sector

vulnerable to rainfall fluctuations and dry spells. Therefore, efficient water conservation methods, such as farm ponds, check dams, and rainwater harvesting, are essential for sustaining agricultural productivity (Fig. 2).

On the other hand, the western, central, and some eastern parts of Anantapur mandal fall under the high rainfall category, receiving approximately 610–691 mm of annual rainfall. These areas receive comparatively greater precipitation, which creates relatively favourable environmental conditions for agriculture and groundwater recharge. The higher rainfall may be attributed to local climatic conditions, topographical influences, and monsoonal variations that enhance precipitation in these regions. Increased rainfall availability supports a wider range of agricultural activities and may allow farmers to cultivate water-demanding crops in addition to traditional dryland crops.

The observed variation in rainfall distribution across Anantapur mandal demonstrates that rainfall is not uniformly distributed and differs significantly from one region to another. This spatial variability has a direct impact on agricultural planning, irrigation development, crop selection, and water resource management. Understanding these rainfall patterns is therefore essential for sustainable development planning in the mandal. Geospatial analysis of rainfall distribution helps policymakers, planners, and farmers identify vulnerable areas, manage water resources efficiently, and implement suitable

adaptation strategies to reduce the adverse effects of climatic variability. Thus, rainfall serves as a crucial environmental factor in determining the socio-economic and agricultural dynamics of Anantapur mandal.

### **Spatial Distribution of Annual Rainfall in Anantapur mandal: 2010**

A detailed distribution of rainfall in the Anantapur mandal for the year 2010, which can be classified into two main rainfall types: moderate rainfall and high rainfall. Moderate rainfall, which ranges from 711 to 768 mm, is distributed in the eastern part of the Anantapur mandal. This means that areas in this region experienced a significant amount of rainfall, which is neither too little nor too much, but just enough for agricultural purposes (fig.3).

On the other hand, the high rainfall, which ranges from 769 to 827 mm, is distributed in the northern, eastern, and central parts of the Anantapur mandal. This means that areas in these regions experienced an abundance of rainfall, which could have provided enough water resources for agricultural purposes in 2010. The presence of high rainfall in the Anantapur mandal could also mean that there are differences in topography, land use, and climatic factors, which could affect the rainfall distribution in the area.

The above analysis of rainfall in the Anantapur mandal for the year 2010 is significant in understanding the spatial variability of rainfall in the area, which could be helpful in water resource management in the region. The analysis of rainfall in the Anantapur mandal for the year 2010 could also be helpful in understanding the effects of drought and floods in the region, which could be addressed through appropriate measures to mitigate the effects of drought and floods in the region.

### **Spatial Distribution of Annual Rainfall in Anantapur mandal: 2024**

The rainfall distribution pattern in Anantapur Mandal for the year 2024 illustrates noticeable spatial variations in precipitation across different parts of the mandal. Based on the analysis, the rainfall pattern can be broadly classified into two major categories, namely low rainfall and moderate rainfall zones. These variations indicate that rainfall is not uniformly

distributed throughout the mandal and that different regions receive different quantities of precipitation. Such spatial differences in rainfall significantly influence agriculture, groundwater availability, vegetation growth, and overall socio-economic activities in the region.

The low rainfall zone, which receives approximately 604–662 mm of annual rainfall, is predominantly concentrated in the north-eastern and north-western parts of Anantapur Mandal. These areas experience comparatively lower precipitation than other regions of the mandal, indicating relatively drier climatic conditions. Since agriculture in Anantapur Mandal is largely dependent on monsoonal rainfall, lower rainfall conditions may create challenges for farming activities, particularly for rainfed agriculture. Farmers in these regions are likely to face difficulties related to soil moisture deficiency, reduced groundwater recharge, and lower agricultural productivity. Crops such as groundnut, millets, pulses, and other drought-resistant crops are generally cultivated in these low rainfall areas because they can tolerate limited water availability.

The reduced rainfall in the north-eastern and north-western regions may also increase the vulnerability of these areas to drought conditions, especially during years of delayed or weak monsoon activity. Insufficient rainfall can adversely affect crop germination, plant growth, and crop yields, thereby impacting the livelihoods of farmers who depend heavily on agriculture. In addition, low rainfall may contribute to declining groundwater levels, drying of tanks and ponds, and increased dependence on borewells for irrigation. Such conditions often lead to water scarcity for both agricultural and domestic purposes. Therefore, sustainable water management practices, including rainwater harvesting, watershed development, drip irrigation, and groundwater conservation measures, become essential in these low rainfall regions.

The spatial rainfall pattern shown in Figure 4 highlights the importance of rainfall variability in determining the environmental and agricultural conditions of Anantapur Mandal. The identification of low rainfall zones through geospatial analysis provides valuable information for regional planning and drought management. Understanding these rainfall patterns can help

government agencies, planners, and local communities implement suitable adaptation strategies to minimize the adverse effects of climate variability. Proper planning based on

rainfall distribution can support efficient utilization of water resources, improve agricultural resilience, and promote sustainable development within the mandal.

### Spatial Distribution of Urban Rainfall (mm) in Anantapur Urban: 2000, 2010 & 2024

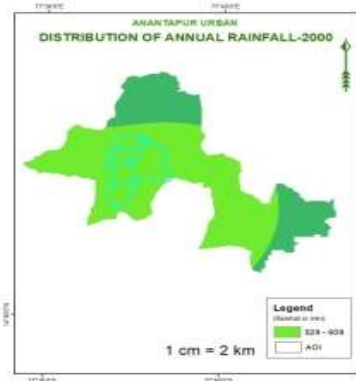


Fig. 5

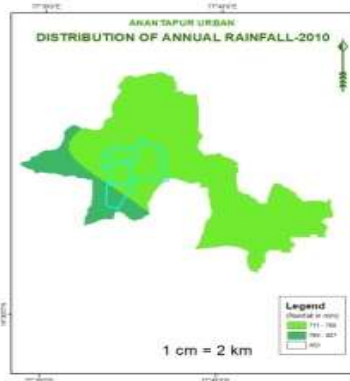


Fig. 6

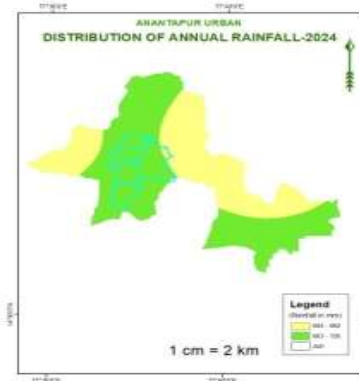
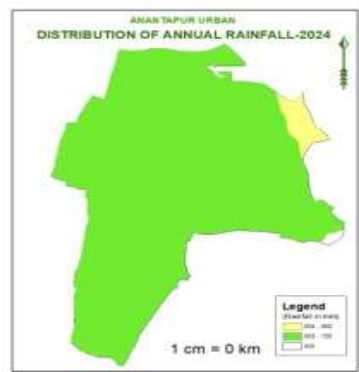
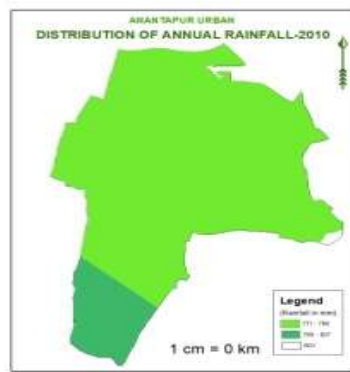
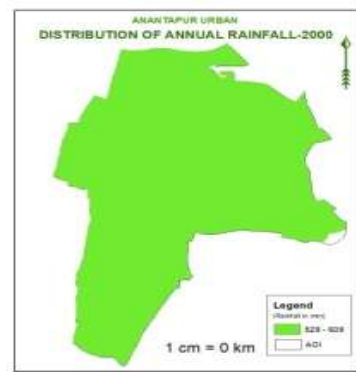


Fig. 7



On the other hand, moderate rainfall, which ranges from 663 to 720 mm, is common in the south-eastern, south-western, and eastern areas of the Mandal. This means that these areas are likely to experience better rainfall, which could have significant effects on the agricultural activities in the region, making them better places for healthy agricultural activities. It is important to note that the division of rainfall into various types is essential in understanding the hydrological pattern of the region, which could affect the land management of the area.

The findings of the research on the rainfall pattern in various areas of Anantapur Mandal for the year 2024 are essential in understanding the effects of rainfall on the environment, which could affect the socio-economic environment of the region.

The demonstrate the rainfall pattern in Anantapur Urban over three different years: 2000, 2010 and 2024. The years are chosen because they are distinct and different. The years were chosen

based on the assumption that they were years when the region experienced low, moderate, and high levels of rainfall. The data indicates that in the year 2000, the region experienced moderate levels of rainfall. The data indicates that the region experienced moderate levels of rainfall. The low levels of rainfall were recorded at 529 mm, and the high levels of rainfall were recorded at 609 mm. The moderate levels of rainfall were recorded at various levels ranging from 529 mm to 609 mm. The data indicates that the region experienced moderate levels of rainfall. The low levels of rainfall were recorded at 529 mm. The high levels of rainfall were recorded at 609 mm. The moderate levels of rainfall were recorded at various levels ranging from 529 mm to 609 mm (fig.5, 6 & 7).

The data indicates that in the year 2010, the region experienced moderate levels of rainfall. The low levels of rainfall were completely absent in the region. The high levels of rainfall were completely absent in the region. The moderate levels of rainfall were recorded at various levels ranging

from 711 mm to 768 mm. The data indicates that in the year 2024, the region experienced low levels of rainfall. The low levels of rainfall were recorded at various levels ranging from 604 mm to 662 mm. The moderate levels of rainfall were recorded at various levels ranging from 663 mm to 720 mm. The high levels of rainfall were completely absent in the region.

### Conclusion:

The analysis of rainfall distribution in Anantapur mandals during the past three years, namely 2000, 2010 and 2024 provides significant insights into climatic changes.

During the year 2010, there is significant variation in rainfall distribution. During this year, there is an increase in rainfall in regions that experienced moderate and high rainfall in previous years. This indicates that there is an increase in rainfall levels in the district. This increase in rainfall is beneficial for agricultural activities in the district. However, there is also a concern that increased rainfall may cause soil erosion.

During the year 2024, there is significant variation in rainfall distribution. Exclusive inferences that can be derived from the analysis of rainfall in Anantapur mandal and the urban area are that there is an increase in rainfall over the years. The transition from low rainfall in 2000 to moderate rainfall in 2010 and beyond in 2024 indicates that there is a significant change in climatic conditions. This is important in urban planning as it indicates that there is a need to develop better infrastructure for rainfall and flooding.

From the findings, it is imperative to understand that rainfall variability and its implications are crucial in understanding the communities and ecosystems. As climate change is dynamic and is likely to continue changing in the coming years, it is imperative to develop effective strategies that will address the issues posed by drought and rainfall in order to certify sustainability in Anantapur. The knowledge gained from this analysis is crucial and can be used as an underlying factor for further research and development aimed at attracting areas' flexibility in the changing climatic environment.

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