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Full Length Research Article

Spatio-Temporal Pattern of Rainfall Pattern in the Handri River Basin using Remote Sensing and GIS

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Abstract

The spatio-temporal distribution of rainfall plays a crucial role in understanding the hydrological dynamics of river basins. In this study, we investigated the spatio-temporal pattern of rainfall in the Handri River Basin using remote sensing and geographic information system (GIS) techniques. The objective was to gain insights into the variability and trends of rainfall patterns over a specific period. Remote sensing data from satellite-based sensors were utilized to estimate precipitation patterns in the study area. These data were processed and analyzed using GIS tools to generate rainfall distribution maps. The study covered a multi-year period, allowing for an assessment of long-term trends and seasonal variations. The results revealed significant spatial variations in rainfall across the Handri River Basin. High rainfall zones were identified in certain regions, while others exhibited relatively lower precipitation levels. The analysis of temporal patterns indicated notable inter-annual and seasonal variations in rainfall distribution. Certain years showed significant deviations from the average precipitation, suggesting the presence of climatic anomalies or extreme weather events. Furthermore, the study highlighted the importance of incorporating remote sensing and GIS techniques for accurate and reliable assessment of rainfall patterns. The integration of these technologies provided a comprehensive understanding of the spatio-temporal dynamics of precipitation, enabling effective water resource management and planning in the Handri River Basin. The findings of this research contribute to the existing knowledge of rainfall patterns in the study area and can serve as a valuable resource for policymakers, water resource managers, and researchers involved in hydrological studies. The study emphasizes the need for continuous monitoring and analysis of rainfall patterns to develop sustainable water management strategies and mitigate the potential impacts of climate change on water resources in the Handri River Basin.

***Key words*:** Rainfall, River Basin, Remote Sensing, GIS, Temporal, Spatial

In recent years, rapid urbanization and increasing human activities have significantly impacted river basins and their associated ecosystems, necessitating the implementation of effective monitoring and management strategies. Remote sensing and Geographic Information Systems (GIS) have emerged as powerful tools for studying and analyzing the spatio-temporal dynamics of river basins, providing valuable insights into the complex interplay between natural processes and anthropogenic influences [1-2]. This manuscript aims to present a comprehensive analysis of river basins utilizing remote sensing data and GIS techniques, shedding light on the evolving environmental patterns and the potential implications for sustainable resource management.

River basins are vital components of Earth's hydrological cycle, encompassing diverse ecological and hydrological systems. They serve as natural conduits for water, nutrients, and sediments, supporting the functioning of ecosystems and ensuring the availability of freshwater resources for human populations. However, these invaluable ecosystems face unprecedented challenges due to population growth, land use changes, and climate variability. Understanding the spatio-temporal dynamics of river basins is crucial for assessing the impacts of these changes, designing effective conservation strategies, and promoting sustainable development [3-4].

Remote sensing, through the acquisition of data from satellites and airborne sensors, provides a unique vantage point for monitoring and studying river basins at various scales. This technology enables the collection of spatially explicit and multi-temporal data, facilitating the identification and characterization of land cover/land use patterns, vegetation

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dynamics, surface water extent, and changes over time [5-6]. Additionally, remote sensing techniques allow the estimation of hydrological parameters such as river discharge, sediment transport, and water quality, which are essential for understanding the health and functioning of river basins.

Complementing remote sensing, GIS offers powerful analytical tools for integrating, visualizing, and analyzing spatial data. By combining remote sensing-derived information with ancillary datasets, such as digital elevation models, soil maps, and socio-economic data, GIS enables the exploration of complex relationships and the identification of spatial patterns within river basins. It allows for the assessment of land use change impacts, the identification of vulnerable areas, and the [7] development of decision support systems for sustainable management.

This manuscript will delve into various aspects of spatio-temporal analysis of river basins using remote sensing and GIS techniques. It will explore case studies highlighting the application of these technologies in monitoring and assessing the impacts of human activities, land use change, climate change, and natural hazards on river basin dynamics. The manuscript will also discuss the potential challenges and future directions in utilizing remote sensing and GIS for improved understanding and management of river basins [8-9]. The integration of remote sensing and GIS has revolutionized the study of river basins, providing researchers, policymakers, and land managers with invaluable tools for monitoring and analyzing environmental changes. This manuscript seeks to contribute to the existing body of knowledge by providing a comprehensive overview of the spatio-temporal analysis of river basins and emphasizing the importance of these technologies in promoting sustainable resource management and environmental conservation in the face of evolving global challenges [9-10].

Water is very important for the survival of all living things. It is the second most important element and comes next only to air. Apart from drinking, it is essential for many economic activities such as agriculture, industries etc. Besides, it is indispensable one for domestic use as well. Water resources of any region depend on rainfall of the respective regions. The failure of rain leads to scarcity of water and affects many economic activities adversely [1-4]. Both our country and the state of Andhra Pradesh depend on monsoon rain for its water resources. Though Southwest monsoon is the major source of rainfall for India, Northeast monsoon is the major source of rainfall for Andhra Pradesh. The monsoon in most parts of the country is erratic and unreliable. In order to assess the nature of rainfall of the state, the annual rainfall and the rainfall of Southwest and Northeast are analyzed in this chapter. Besides, an attempt has been made to analyze the deviation and variability of rainfall in the Handri river Basin, Kurnool, Andhra Pradesh.

MATERIALS AND METHODS

Study area

Handri river basin of Kurnool district, Andhra Pradesh, India is selected having the different physiographic areas. The Handri river basin originates from Pattikonda and Dhone foothills area from Kurnool district and it merges in Penna River at Kurnool district in Andhra Pradesh. Handri River basin is a sub tributary of Penna River originates from Kurnool district. Handri River is located between 77° 16’ 50’’ E to 78° 07’ 55’’ E longitudes and 15° 11’ 50’’ N to 15° 50’ 38’’ N latitudes covering an area of 3538.90 km^2. The study area is included in the Survey of India (SOI) Toposheet No’s 57E/10, 57E/6, 57E/16, 57E/12, 57E/8, 57I/3, 57E/15, 57E/11, 57E/7, 57I/2, 57E/14, 57I/1, and 57E/13 at a scale of 1: 50,000 (Fig 1). The physiography of the study area consists of mountains, ridges and hills forming gentle rolling topography. Alluvial plains are along the river courses where mainly alluvial deposits are found. The area has undulating topography and meandering streams.

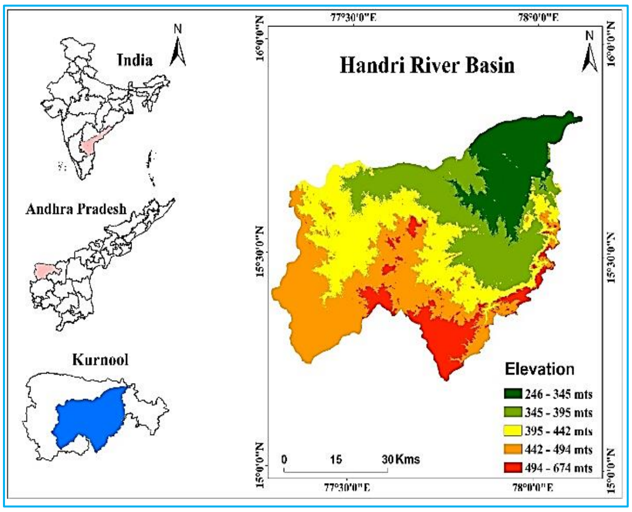

Fig 1 Location map of the study area

The purpose of this methodology is to provide a step-by-step guide for collecting rainfall data using the NASA POWER (Prediction of Worldwide Energy Resource) website. The NASA POWER website provides access to a wide range of climate and weather data, including precipitation measurements. This methodology will help users navigate the website and retrieve accurate and reliable rainfall data.

Website navigation

To get started, open a web browser, and visit the NASA POWER website at https://power.larc.nasa.gov. Take some time to explore the various sections and tools offered on the site, including the Data Access Viewer, Data Sets, and Interactive Data Access. Make sure you have a stable internet connection to ensure smooth access to the website and seamless retrieval of data.

Selecting the region of interest

To begin accessing data on the NASA POWER homepage, navigate to the "Data Access Viewer" segment and select the "Launch" button. Inside the Data Access Viewer, employ the map navigation controls to zoom in or out and pan until you locate your desired region. You can then use the search box or manual selection tools to precisely define the geographic area of interest for rainfall data collection. If needed, make adjustments to the date and time range to select the specific period for data collection.

Rainfall data selection

To access the required data in the Data Access Viewer, navigate to the "Variables" section and click to expand it. Look for the "Precipitation" category and choose the specific rainfall variable that aligns with your needs. You'll find options like daily precipitation, monthly precipitation, or other relevant variables. Indicate your desired temporal resolution, such as daily or monthly, and specify the temporal average you prefer, such as mean or sum, for the rainfall data [7]. Make any necessary adjustments to data format, units, or spatial resolution according to your requirements.

Data download and export

Once you've set up the rainfall data selection parameters, simply click the "Add to Cart" button. Double-check the cart to verify that the chosen variables and options are accurate. Proceed to the next step by clicking "Checkout." Here, you'll need to provide essential information such as your name and email for data delivery. Select your preferred data format for download, like NetCDF or CSV, and choose any additional options for data processing or visualization [8]. Submit the data order and patiently wait for an email notification containing the download link. Access the provided link to retrieve the rainfall data in your selected format.

Data quality check

After receiving the downloaded rainfall data, it is essential to verify the file's integrity and completeness. Make sure to examine the data format to ensure it aligns with the format selected during the order process. Additionally, validate the units, temporal resolution, and spatial coverage of the downloaded data to ensure they meet your specific research or analysis needs.

Data analysis and interpretation

To effectively analyze the rainfall data, begin by importing it into your preferred analysis software or programming environment. Next, execute essential data processing steps, such as data cleaning and aggregation, to ensure the data is prepared for analysis. Utilize appropriate statistical methods, visualization tools, and any other relevant techniques to gain meaningful insights from the rainfall data. Be sure to thoroughly document the analysis methodology, including any findings or insights derived from the examination of the rainfall data [2].

RESULTS AND DISCUSSION

Handri river basin – Annual rainfall decade – I (2002 -2011)

Annual rainfall is an important climatic variable that has a significant impact on various aspects of human life and ecosystems. The amount of rainfall received in a region can affect agriculture, water resources, and even human health. Looking at a decade of annual rainfall can provide valuable information on long-term trends in precipitation patterns. For instance, if the annual rainfall is consistently high or low over a decade, it could indicate a shift towards wetter or drier conditions. Additionally, comparing the annual rainfall of a particular decade with historical records can provide insights into whether the precipitation patterns are changing over time [11-12]. However, it is important to note that annual rainfall can vary significantly from year to year, and a single decade may not be representative of long-term climate patterns. Therefore, it is crucial to examine long-term trends in precipitation patterns to better understand how rainfall patterns are changing and how they might impact ecosystems and human societies,

Table 1 Annual rainfall of decade I (2002 – 2011) in the study area

S. No	Rainfall in mm	Level	Mandals
1	584.83 - 613.52	Very Low	Adoni, Aspari, Alur, Maddikera, Pattikonda and Yemmiganur
2	613.52 - 642.20	Low	Dhone and Devanakonda
3	642.20 - 670.88	Moderate	Krishnagiri and Gonegandla
4	670.88 - 699.56	High	Kodumur, Veldurthi, Gudur and Orvakal
5	699.56 - 728.25	Very High	Kallur and Kurnool

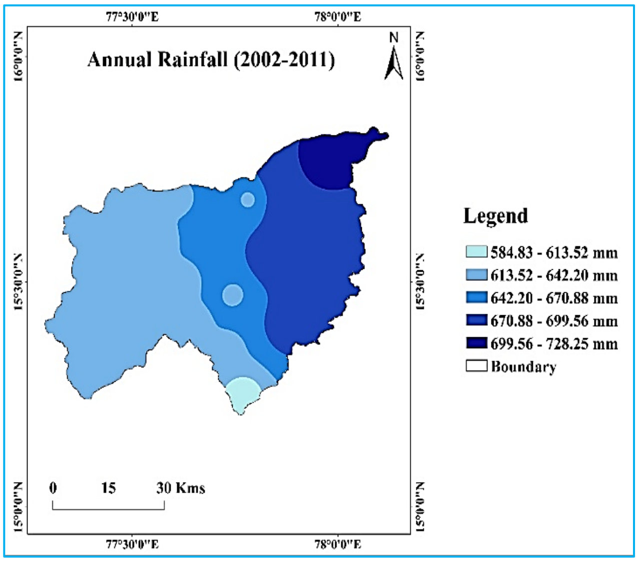

Fig 2 Annual rainfall decade I (2002 - 2011) of the study area

Data depicted in (Table 1, Fig 2) shows the spatial distribution of rainfall in Handri river basin for decade-I (2002-2011). The Handri River Basin experiences varying degrees of rainfall throughout the year, influencing the water availability and ecosystem of each region. In areas classified as "Very Low" rainfall, such as Adoni, Aspari, Alur, Maddikera, Pattikonda, and Yemmiganur, the annual precipitation ranges between 584.83 mm and 613.52 mm. These areas tend to receive relatively minimal rainfall, which can have implications for agriculture, water resources, and overall environmental conditions. Moving to areas classified as "Low" rainfall, including Dhone and Devanakonda, the annual precipitation increases slightly to a range between 613.52 mm and 642.20 mm. While these regions experience a higher level of rainfall compared to the previous category, it remains relatively low. This can affect the overall water supply and cultivation patterns in these areas.

The "Moderate" rainfall category encompasses Krishnagiri and Gonegandla, where the annual rainfall falls within the range of 642.20 mm to 670.88 mm. These regions receive a moderate amount of precipitation, which can have positive impacts on agriculture and vegetation. Moving up the scale, the "High" rainfall category includes Kodumur, Veldurthi, Gudur, and Orvakal, experiencing annual rainfall between 670.88 mm and 699.56 mm. These areas receive a relatively high amount of rainfall, contributing to improved water availability and enhanced agricultural productivity. Finally, the "Very High" rainfall category comprises Kallur and Kurnool, where the annual precipitation ranges between 699.56 mm and 728.25 mm. These regions receive the highest amount of rainfall in the Handri River Basin, which can have significant implications for agriculture, hydrology, and the overall ecology of the area.

Understanding the annual rainfall patterns in the Handri River Basin and its distribution across different regions helps in assessing water resources, agricultural potential, and environmental conditions. The variations in rainfall levels within the basin highlight the diverse nature of the region and its dependence on water availability for various socioeconomic activities.

Handri river basin – Annual rainfall decade – II (2012 -2021)

Data depicted in (Table 2, Fig 3) show the spatial distribution of rainfall in Handri river basin for decade-I (2012-2021). The annual rainfall in the Handri River Basin from 2012 to 2021 exhibited a range of levels across various mandals. The rainfall levels were categorized based on the amount of precipitation received. At the lower end, Peapally experienced very low rainfall, with values ranging between 532.06 and 551.82 millimeters. Moving up the scale, several mandals including Adoni, Aspari, Dhone, Alur, Pattikonda, Devankonda, and Yemiganur encountered low rainfall, ranging from 551.82 to 571.57 millimeters. Devanakonda and Gonegandla witnessed moderate rainfall in the range of 571.57 to 591.33 millimeters. The high rainfall category was observed in Krishnagiri and Kodumur, where the precipitation ranged from 591.33 to 611.09 millimeters. Finally, Kodumur, Gudur, Kurnool, Kallur, and Veldurthi experienced very high rainfall, reaching levels between 611.09 and 630.84 millimeters. These variations in rainfall levels across different mandals contributed to the overall hydrological dynamics of the Handri River Basin during the period of 2012-2021.

Table 2 Annual rainfall of decade II (2012 – 2021) in the study area

S. No	Rainfall in mm	Level	Mandals
1	532.06 - 551.82	Very Low	Peapally
2	551.82 - 571.57	Low	Adoni, Aspari, Dhone, Alur, Pattikonda, Devankonda and Yemiganur
3	571.57 - 591.33	Moderate	Devanakonda and Gonegandla
4	591.33 - 611.09	High	Krishnagiri and Kodumur
5	611.09 - 630.84	Very High	Kodumur, Gudur, Kurnool, Kallur and Veldurthi

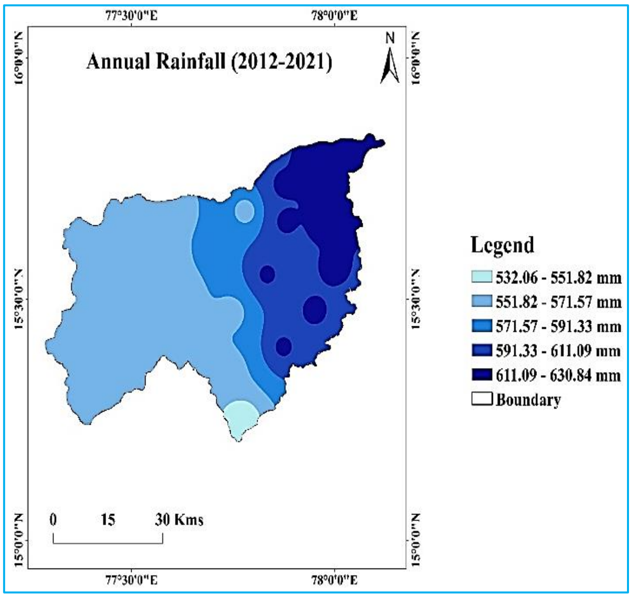

Fig 3 Annual rainfall decade II (2012 - 2021) of the study area

Trend of annual rainfall (2002-2021)

A comparative trend analysis of rainfall can be observed between the two tables provided. In the first table, the mandals of Adoni, Aspari, Alur, Maddikera, Pattikonda, and Yemmiganur experienced very low rainfall levels, ranging from 584.83 mm to 613.52 mm. Dhone and Devanakonda mandals received relatively low rainfall, ranging from 613.52 mm to 642.20 mm. Krishnagiri and Gonegandla mandals recorded moderate rainfall levels, ranging from 642.20 mm to 670.88 mm. The mandals of Kodumur, Veldurthi, Gudur, and Orvakal experienced higher rainfall levels, ranging from 670.88 mm to 699.56 mm. Lastly, Kallur and Kurnool mandals received very high levels of rainfall, ranging from 699.56 mm to 728.25 mm.

Comparing this with the second table, Peapally mandal had the lowest rainfall levels, ranging from 532.06 mm to 551.82 mm. Adoni, Aspari, Dhone, Alur, Pattikonda, Devankonda, and Yemiganur mandals received low levels of rainfall, ranging from 551.82 mm to 571.57 mm. Devanakonda and Gonegandla mandals recorded moderate rainfall levels, ranging from 571.57 mm to 591.33 mm. Krishnagiri and Kodumur mandals experienced higher rainfall levels, ranging from 591.33 mm to 611.09 mm. Finally, Kodumur, Gudur, Kurnool, Kallur, and Veldurthi mandals received very high levels of rainfall, ranging from 611.09 mm to 630.84 mm.

Overall, there are similarities and differences in the rainfall patterns between the two tables. Some mandals consistently experienced similar rainfall levels, such as Adoni, Aspari, Alur, and Pattikonda. However, there are also variations in rainfall levels for certain mandals, highlighting the potential variability of rainfall within the region.

CONCLUSION

The spatio-temporal pattern of rainfall in Handri river basin, Andhra Pradesh, India. It specifically examines the variations in rainfall during different seasons, including summer, winter, annual, southwest monsoon, and northeast monsoon rainfalls. The summer season in Kurnool is characterized by hot and dry weather conditions. Rainfall during this period is generally scarce, with minimal precipitation occurring sporadically. The chapter analyzes historical data to identify any discernible patterns or trends in summer rainfall, highlighting the region's arid climate. However, there are also variations in rainfall levels for certain mandals, highlighting the potential variability of rainfall within the region. The encouraging scenario obtained by trend analysis of rainfall is that the increasing trend is noticed in 6 mandals of the river basin. It shows that there was an increase in rainfall increasing Trend in rainfall from decade to decade. The Increase in rainfall does not mean that the rainfall is excess. The mandals of Adoni, Aspari, Alur, Maddikera, Pattikonda, and Yemmiganur experienced precipitation levels between 584.83 mm and 613.52 mm. The rainfall in Dhone and Devanakonda mandals was relatively low, ranging from 613.52 mm to 642.20 mm. The Krishnagiri and Gonegandla mandals received moderate precipitation, ranging from 642.20 to 688.8 mm.

Kodumur, Veldurthi, Gudur, and Orvakal experienced higher levels of precipitation, ranging from 670.88 to 695.56 mm. Lastly, the mandals of Kallur and Kurnool received precipitation totaling between 699.56 mm and 728.25 mm. The Peapally mandal had the lowest range of precipitation, from 532.06 to 551.82 mm. Adoni, Aspari, Dhone, Alur, Pattikonda, Devankonda, and Yemiganur mandals received between 551.82 and 571.57 mm of precipitation. Devanakonda and Gonegandla mandals experienced moderate precipitation, ranging from 571.57 mm to 591.33 mm. The rainfall totals in the mandals of Krishnagiri and Kodumur ranged from 591.33 mm to 609.9 mm. Kodumur, Gudur, Kurnool, Kallur, and Veldurthi mandals received exceptionally high amounts of precipitation, ranging from 611.09 to 630.84 mm. There are similarities and differences precipitation patterns. Some mandals, such as Adoni, Aspari, Alur, and Pattikonda, consistently encountered the same precipitation levels. Nonetheless, there are variations in rainfall levels between mandals, highlighting the potential for rainfall variability in the region. The findings aim to enhance our understanding of the spatio-temporal dynamics of rainfall in Kurnool, aiding in water resource management, agriculture planning, and climate change studies in the region.

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