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Analyzing the Influence of Precipitation Patterns on Groundwater Fluctuations during Post Monsoon

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Abstract: Annual rainfall plays a crucial role in groundwater recovery, with higher rainfall years typically resulting in improved levels. However, some regions still struggle with recharge due to runoff, excessive extraction, or unfavorable geological conditions.

The variations indicate that while monsoonal rainfall contributes significantly to groundwater replenishment, local factors such as landuse, urbanization and aquifer characteristics also impact water availability. Addressing these disparities requires sustainable water management strategies, including rainwater harvesting, artificial recharge methods, and controlled groundwater extraction.

Efficient irrigation techniques and stricter regulations on water use should be implemented in areas facing declining or highly fluctuating levels.

The analysis of groundwater levels in Rangareddy district from 2015 to 2019, considering post-monsoon data alongside rainfall records. Groundwater levels generally improve in post-monsoon due to recharge, but the extent of replenishment varies across mandals.

Talakondapalle, Maheshwaram, and Yacharam consistently recorded deeper water levels, often exceeding 15–25 meters, indicating slow recharge or high extraction, whereas Rajendranagar, Ibrahimpatnam, and Serilingampally showed relatively shallow levels, suggesting efficient recharge or lower withdrawal.

Some areas, such as Farooqnagar and Hayathnagar, exhibit substantial fluctuations, likely influenced by hydrogeological conditions and water demand. Promoting community awareness and strengthening conservation policies can help to ensure long-term groundwater sustainability.

An integrated approach combining scientific monitoring, policy interventions, and local participation is essential to mitigate water scarcity and ensuring resilience against future climatic uncertainties in the region.

Keywords: Groundwater levels, water extraction, hydrogeological conditions, water management, rainwater harvesting, groundwater sustainability, climatic uncertainties.

I. INTRODUCTION

India is the largest global consumer of groundwater, utilizing approximately 235 billion cubic meters (BCM), with key sectors such as drinking, residential use, irrigation, and industry relying heavily on it. Groundwater, also known as subsurface water, is found beneath the Earth's surface in soil and geological layers, and has long served as a vital resource for economic activities, especially in urban and industrial sectors.

With the increasing decentralization of water supply systems, particularly among farmers, groundwater is becoming a preferred resource. To effectively manage and understand groundwater resources, it is essential to integrate large volumes of high-quality data from multiple sources. This study aims to analyze fluctuations in groundwater levels.

A. Objectives

The main objectives of the work are

1) To assess the variations in precipitation within the study area from 2015 to 2019.
2) To examine groundwater levels during the post-monsoon period from 2015 to 2019.

II. STUDY AREA

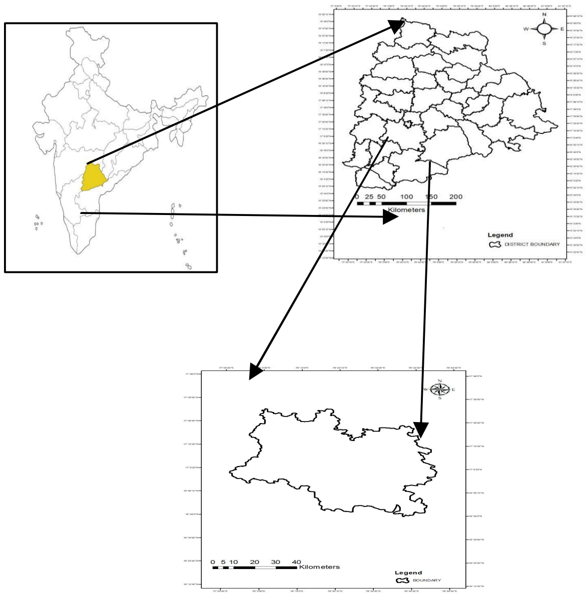

Fig -1 Location of the Study Area

The study area is Rangareddy District, located in the central part of the Deccan Plateau in Telangana, India. The district spans over an area of 5,031 square kilometers and is situated between 16°41’51” and 17°31’32”' North Latitude and 77°53’14” and 78°50’38” East Longitude. The altitude of Rangareddy is 544 meters. The climate in the region is classified as Tropical Wet and Dry, characterized by semi-dry summers and cooler winters. The district experiences maximum temperatures ranging from 22°C to 44°C and minimum temperatures between 13.8°C and 21°C. Annual rainfall ranges from 650 mm to 1,260 mm, with an average precipitation of approximately 890 mm. The Musi River, along with the Manjeera River (a tributary of the Godavari River), flows in a northern direction through the district. The major soils in the region include red earth, consisting of loamy soil, sandy loam, and sandy clay loams, covers 70% of the area. Additionally, red and black soils, including clay loams, clays, and silty clays, covers 20% of the district. The remaining 10% is occupied by mixed soils.

III. METHODOLOGY

The methodology for investigating the impact of groundwater fluctuations on rainfall combines data collection and statistical analysis. This study area is selected based on its vulnerability to groundwater fluctuations and the availability of reliable data. Groundwater level data is gathered from monitoring wells over an extended period, while rainfall data is sourced from local meteorological stations. Statistical methods, including correlation and time-series analysis, assess the relationship between groundwater fluctuations and rainfall, accounting for time lags between precipitation events and changes in groundwater. Field observations from areas with different groundwater conditions offer insights into how fluctuations influence rainfall frequency and intensity. This approach aims to identify feedback mechanism where altering rainfall patterns causes significant groundwater fluctuations in the study area.

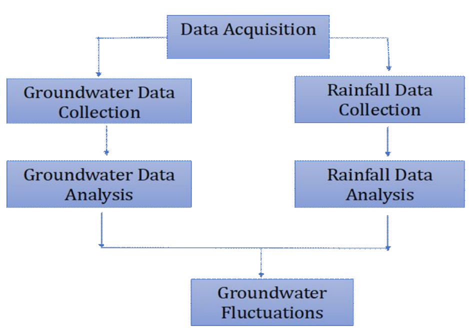

Fig -2: Methodology for ground water fluctuations

IV. RESULTS AND DISCUSSIONS

A. Rainfall Analysis

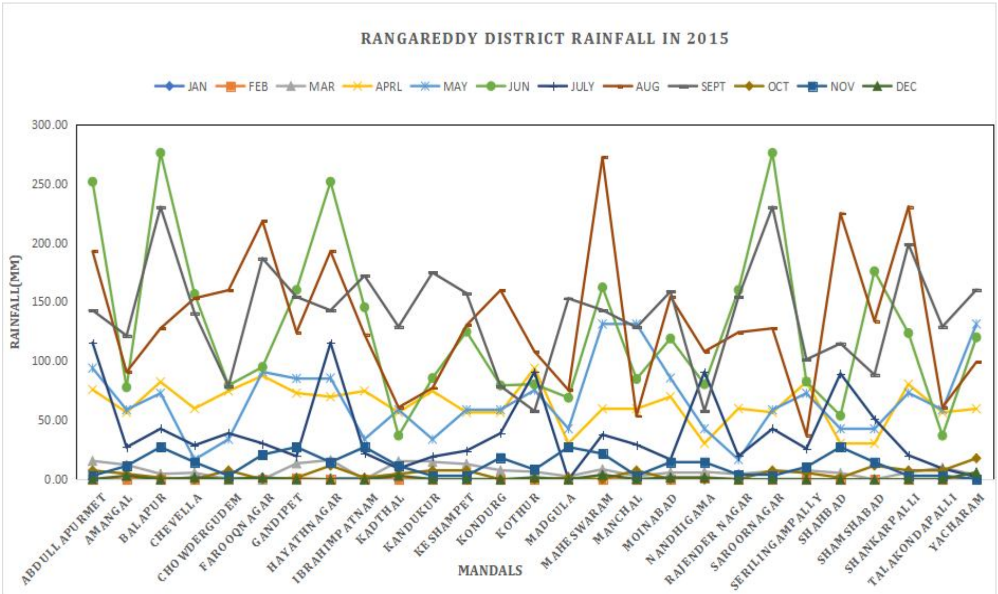

Fig 3 Variation of rainfall in Rangareddy District during 2015

In 2015, Hayathnagar recorded the highest annual rainfall among all mandals, accumulating a total of 1076.72 mm. In contrast, Talakondapalle received the least rainfall, with an average annual rainfall of 431.22 mm. In the month of June 2015, the highest monthly rainfall of 275.8 mm has been recorded in Balapur mandal. It has been observed that zero rainfall has occurred in Kothur mandal in the study area indicating an absence of significant precipitation during that period.

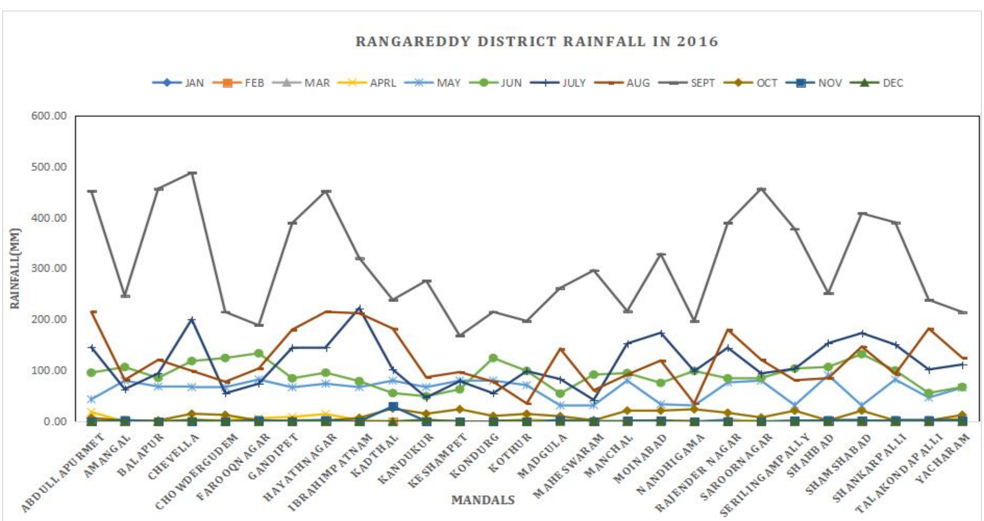

Fig 4 Variation of rainfall in Rangareddy District during 2016

In 2016, Hayathnagar recorded the highest annual rainfall at 1003.78 mm, while Nandigam received the lowest, with an average rainfall of 486.24 mm. September recorded the highest rainfall of 487.8 mm in Chevella whereas the lowest rainfall is observed in Keshampeta, indicating dry conditions in that region during the same period.

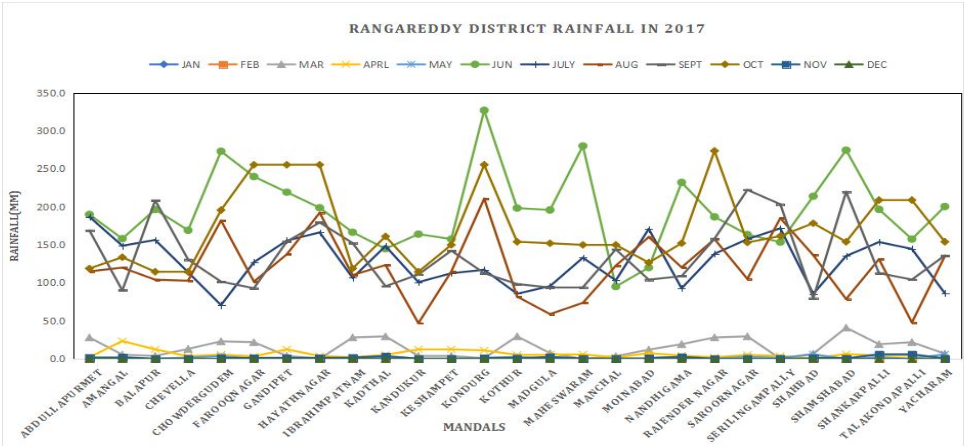

Fig 5 Variation of rainfall in Rangareddy District during 2017

In 2017, Kondurg recorded the highest annual rainfall of 1038.24 mm, while Kandukur received the lowest rainfall of 555.29 mm. June recorded the highest monthly rainfall in Kondurg measuring 327.0 mm, whereas Balapur experienced the lowest, with 0.0 mm in October month, indicating dry conditions during that period.

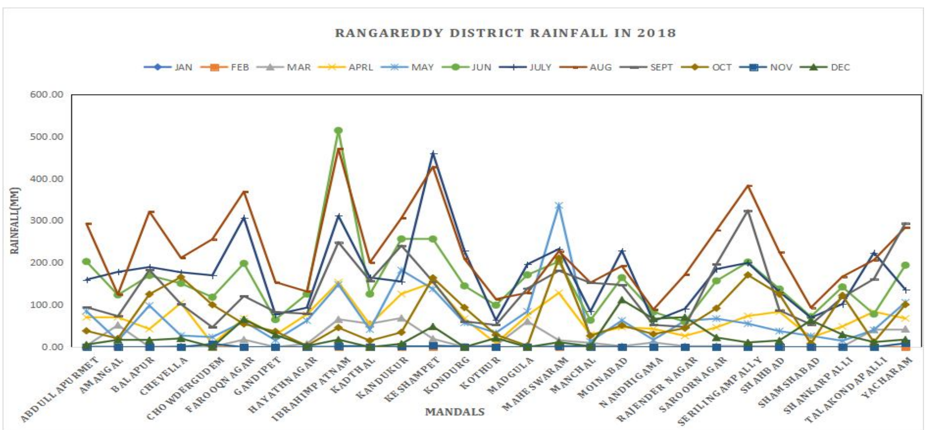

Fig 6 Variation of rainfall in Rangareddy District during 2018

In 2018, Ibrahimpatnam received the highest annual rainfall of 1980.3 mm, while Shamshabad recorded the lowest rainfall of 411.4 mm. June experienced the highest monthly rainfall, with Ibrahimpatnam measuring 514.0 mm, whereas Nandigam recorded the lowest, with 0.0 mm in August, indicating absence of rainfall during that period.

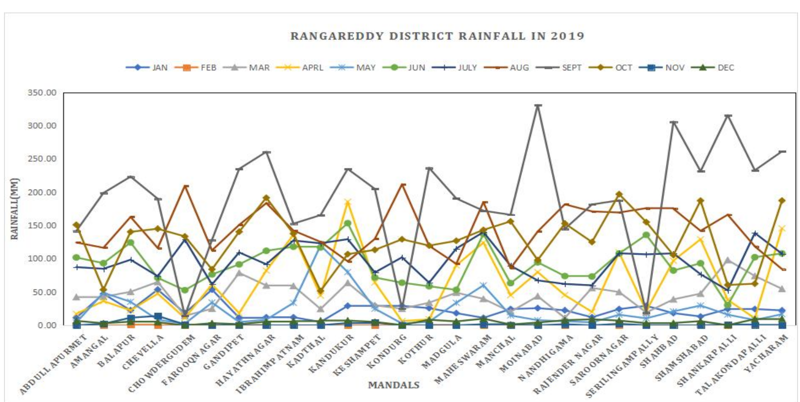

Fig 7 Variation of rainfall in Rangareddy District during 2019

In 2019, Serilingampally recorded the highest annual rainfall of 1374.1 mm, while Farooqnagar received the lowest rainfall of 581.1 mm. Regarding monthly extremes, the highest recorded value corresponds to the total annual rainfall rather than a specific month, indicating a possible issue in the dataset that prevents identifying the peak monthly rainfall separately. Meanwhile, the lowest monthly rainfall was 0.0 mm, which was observed in Farooqnagar mandal.

B. Groundwater Levels Analysis

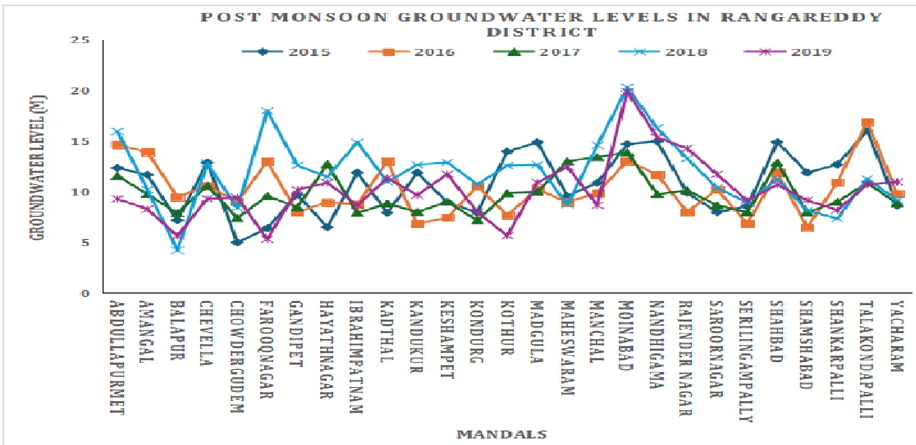

Fig 8 Variation of Groundwater Levels in Rangareddy District during post monsoon

The graph presents post-monsoon groundwater levels across various mandals in Rangareddy district from 2015 to 2019. The data reveals that groundwater levels generally improve after the monsoon, though the extent of recharge varies. Mandals such as Talakondapalle and Maheshwaram consistently have deeper water levels, often exceeding 15 meters, suggesting slower recharge rates or higher water usage. In contrast, areas like Rajendranagar, Ibrahimpatnam, and Serilingampally exhibit shallower levels, occasionally below 5 meters, indicating more effective recharge or lower extraction rates. Some mandals, including Farooqnagar and Hayathnagar, display significant fluctuations in water levels, likely influenced by factors such as rainfall patterns, hydrogeological conditions and groundwater consumption. The overall trend suggests that while post-monsoon replenishment occurs, its effectiveness varies across different locations.

V. CONCLUSIONS

The study of groundwater levels in Rangareddy district from 2015 to 2019, considering pre-monsoon and post-monsoon variations alongside rainfall data, highlights the critical role of seasonal recharge in water availability. While post-monsoon levels generally show improvement, the extent of recharge varies significantly across mandals due to factors such as rainfall distribution, extraction rates, and hydrogeological conditions. Areas like Talakondapalle, Maheshwaram, and Yacharam face persistent groundwater depletion, whereas mandals like Rajendranagar, Ibrahimpatnam, and Serilingampally exhibit better recharge efficiency. The data suggests that while monsoonal rainfall is a key contributor to groundwater replenishment, excessive extraction and urbanization pose challenges to sustainable water management. To mitigate depletion and ensure long-term groundwater sustainability, measures such as rainwater harvesting, artificial recharge, efficient irrigation, and regulated groundwater extraction must be prioritized. Additionally, strengthening conservation policies and promoting community participation will be essential in addressing water scarcity challenges. An integrated approach combining scientific research, policy implementation, and local engagement is necessary to enhance groundwater resilience and secure water resources for the future.

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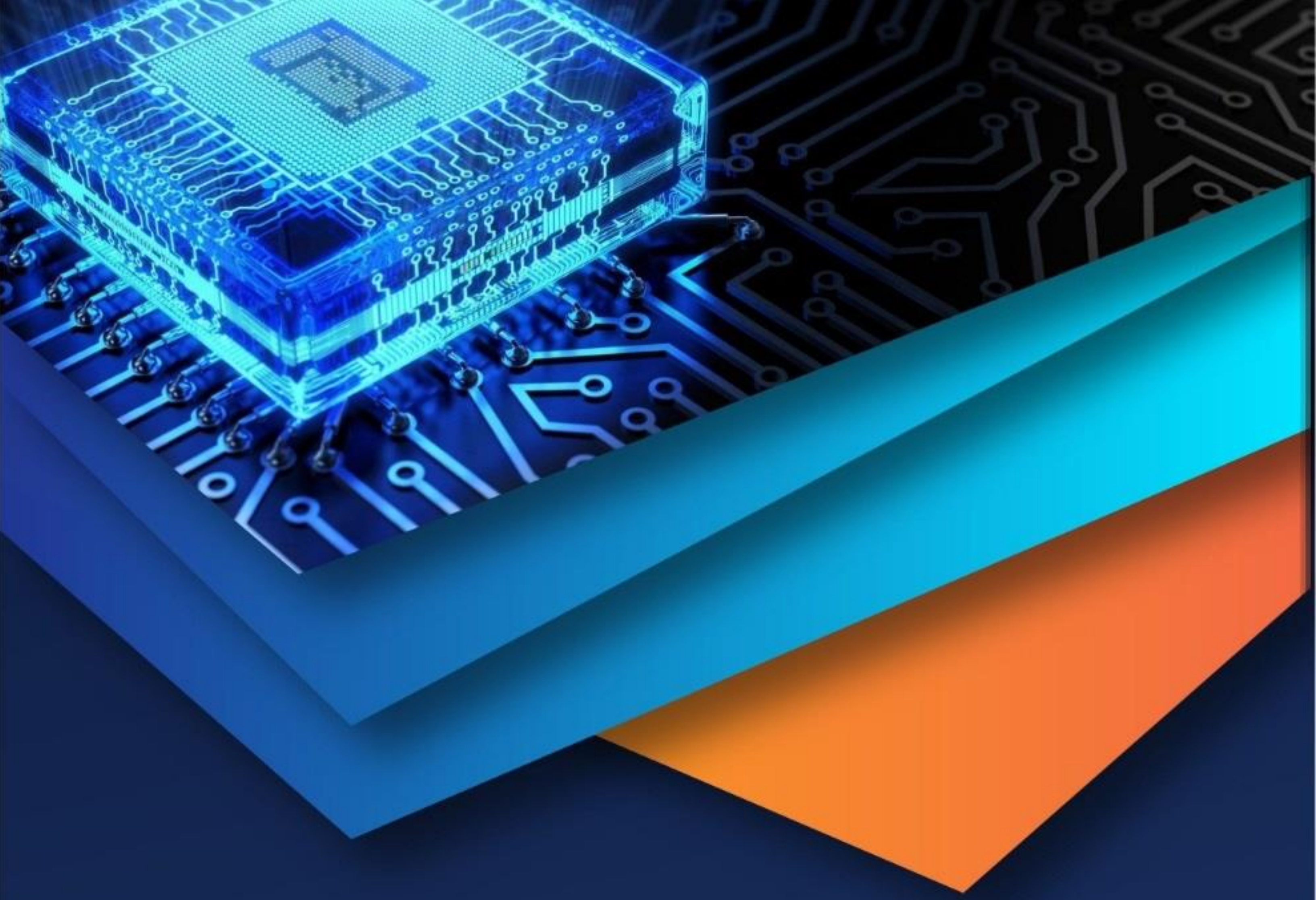

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