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Original Article

A Study on Water Availability and Crop Pattern Analysis For Kharif and Rabi Seasons at Joint Director Agriculture Office with Reference to National Informatic Center, Anantapur

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Abstract: *This study examines the crop pattern relationship on different irrigation methods and the seasonal variations for both kharif and rabi. The study focuses on variations in irrigation methods and its effects on crop performance across different irrigation sources, including canals, tanks, tube wells, and surface flow. Using statistical methods such as two-way ANOVA in Python, the research identifies the significant effects of different irrigation methods and seasons on crop performance. Visual tools like line plots and box plots are utilized to illustrate trends and patterns over four years (2021–2025). Key crops analysed in the study include paddy, maize, groundnut, green chilli, and tomato. The findings contribute to a better understanding of sustainable agricultural practices by aiding decision-making for resource optimization and enhanced productivity. The study's insights aim to support informed strategies for effective water resource management in Anantapur district.*

Keywords: *Water Availability, Crop Pattern Analysis, Kharif Season, Rabi Season, Irrigation Methods, ANOVA.*

I. INTRODUCTION

The agricultural sector of Anantapur, which is a district located in the semiarid region of Andhra Pradesh state, India, heavily depends on monsoon rainfall, but this source is both erratic and inadequate. As agriculture is the main source of income for most populations in this region, water availability will be key to economic well-being and food security. The cropping system of the district comprises two seasons: Kharif (monsoon) and Rabi(winter). The seasonal variability in water availability and its impact on crop patterns are key to sustainable agricultural development. The Joint Director of Agriculture (JDA) office, Anantapur is the centralized command point for agricultural policy implementation and resource distribution in addition to crop monitoring in the district. The JDA office works hand-in-hand with the National Informatics Centre (NIC) while managing agriculture-related work backed by data-driven insights. This study is an analysis of water availability from sources like canals, tanks and tube wells on the choice and productivity of major crops (paddy, maize and groundnut).

The need for this study arises from the increasing pressure on water resources due to climate change and growing agricultural demands. There is a critical requirement to evaluate how different irrigation methods contribute to crop success and to identify patterns that can lead to more efficient water use. The scope of this research is limited to the Anantapur district, utilizing data from the 2021-2025 period to provide a contemporary analysis of seasonal variations. The primary objectives of this study are to assess the availability of water from different irrigation sources for both the Kharif and Rabi seasons and to examine the distribution of crop areas under various irrigation methods. Furthermore, the research aims to analyze the impact of seasonal changes on crop patterns and identify the most effective irrigation strategies for enhancing agricultural productivity in the region. Through statistical analysis and data visualization, this study seeks to provide actionable insights for policymakers and farmers to optimize resource management.

II. LITERATURE REVIEW

A) Research Methodology:

The methodology of this study is grounded in quantitative analysis, utilizing secondary data to evaluate the relationship between water availability and cropping patterns. Data was meticulously gathered from the records of the Joint Director of Agriculture office and the National Informatics Centre in Anantapur, covering a five-year period from 2021 to 2025. This timeframe allows for a comprehensive assessment of trends across both the Kharif and Rabi seasons, focusing on major crops including paddy, maize, groundnut, green chili, and tomato.

B) Tools and Techniques:

To ensure statistical rigor, the study employs the Two-Way Analysis of Variance (ANOVA) technique. This method is used to examine the influence of two independent variables, irrigation source (canals, tanks, tube wells, and surface flow) and

cropping season, on the dependent variable, which is the total area of crop production. The analysis was conducted using Python programming, leveraging data science libraries to process the agricultural metrics and validate the research hypotheses.

C) Limitations of the Study:

The data is plotted using line plots, box plots and summarized charts. This makes it easier to detect patterns of changes in water availability and distribution of crops that may not be easily visible from the raw population data tables. The study has limitations, including dependence on available secondary records and the bounding of results to a geographical area, the Anantapur district, which serves as the main delimiter for the findings from this research.

III. RESULTS AND DISCUSSION

From 2021 to 2025, an analysis of the availability of water and crop patterns in Anantapur shows high dependency on groundwater sources. According to the data compiled by the Joint Director of Agriculture office, tube wells continue to be the main source of irrigation for both Kharif and Rabi seasons. Agriculture is supplemented by the use of canals and tanks, but these sources are seasonal, and their availability depends on the agricultural intensity of the monsoon. The trend analysis results present that there was almost a horizontal line for the water supply from surface flow (SP) as compared to tube well irrigation area coverage, which shows a significant increase in the areas where crop production systems have been adapted by local farmers due to scarcity of surface water.

A) Kharif Season Crop Area Analysis for Year 2025

Kharif Season (2025): Out of the crops, the cultivation of Paddy covers the maximum area of 21,606 hectares, followed by Maize with 19,973 hectares and Tomato with 16,810 hectares. Chilli takes up 14,354 hectares, and Groundnut takes up 11,321 hectares.

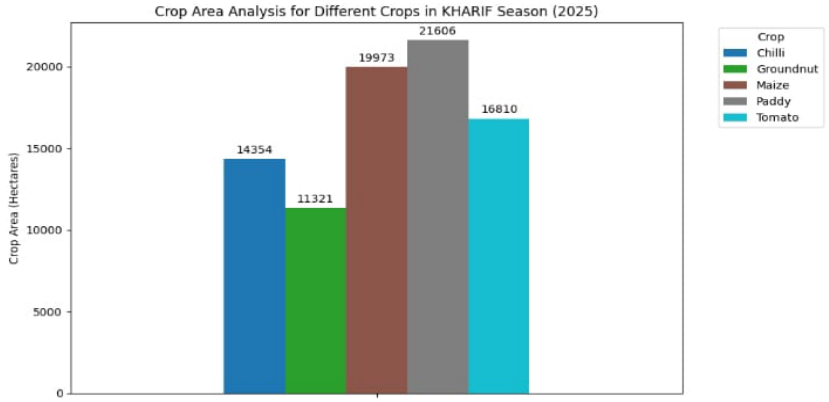

Figure 1. Kharif Season Crop Area 2025

B) Rabi Season Crop Area Analysis for Year 2025

Rabi Season (2025): Out of the crops, the cultivation of Paddy covers the maximum area of 5,675 hectares, followed by Maize with 16,550 hectares and Tomato with 1,875 hectares. Chilli takes up 140 hectares, and Groundnut takes up 17,320 hectares.

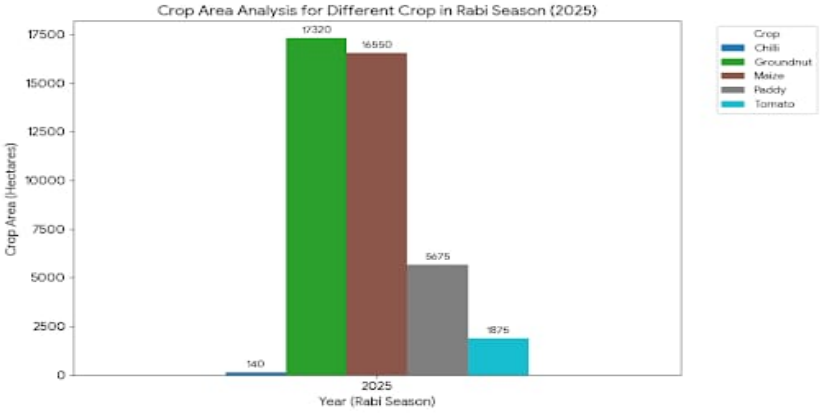

Figure 2. Rabi Season Crop Area 2025

C) Kharif Season Crop Area Analysis for Year (2021-2024)

Kharif Season: Out of the crops, from 2021 to 2024, illustrates a period of significant agricultural expansion and shifting crop priorities, culminating in a high-output 2024 across almost all categories. While Paddy remained a consistent staple with a steady climb to 21,606 units by 2024, the most striking fluctuations occurred in specialty crops; specifically, Tomato cultivation saw an anomalous, massive spike to 25,092 units in 2023 before settling at a still robust 16,810 the following year. The 2024 season was particularly noteworthy for its diversification, as Maize, Groundnut, and Green Chilies the latter of which exploded from just 907 units in 2023 to 14,354 units, all reached multi-year peaks. This trend suggests a move toward more intensive and varied farming practices, with 2024 serving as a standout year for total land utilization across these five major crops.

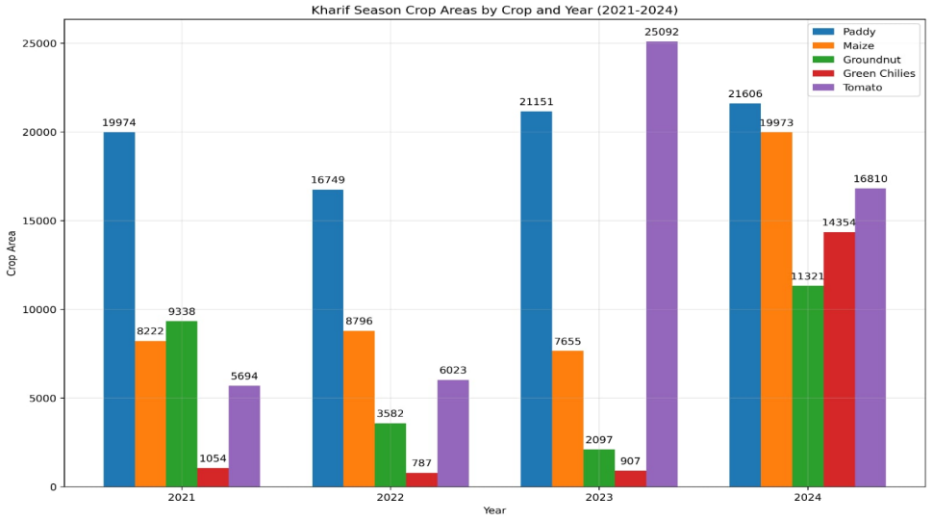

Figure 3. Kharif Season Crop Area 2021-2024

D) Rabi Season Crop Area Analysis for Year (2021-2024)

Rabi Season: Out of the crops, from 2021 to 2024, reveals a significant shift in crop prioritization, most notably marked by the steady decline of Groundnut and the rapid ascent of Maize. While Groundnut began as the dominant crop in 2021 with 28,310 hectares, its footprint has consistently contracted, falling to 16,500 hectares by 2024. In stark contrast, Maize cultivation has surged nearly fourfold, climbing from 3,657 hectares to 15,500 hectares over the same period, suggesting a strong pivot toward cereal and fodder production. Paddy also saw a notable increase, doubling from its 2021 baseline to reach 6,800 hectares, while speciality crops like Tomato and Green chilli remained marginal, with Tomato area gradually tapering off to 1,500 hectares. Overall, the data highlights a transition toward a more balanced Rabi output, with Maize nearly achieving parity with the traditionally dominant Groundnut by the 2024 season.

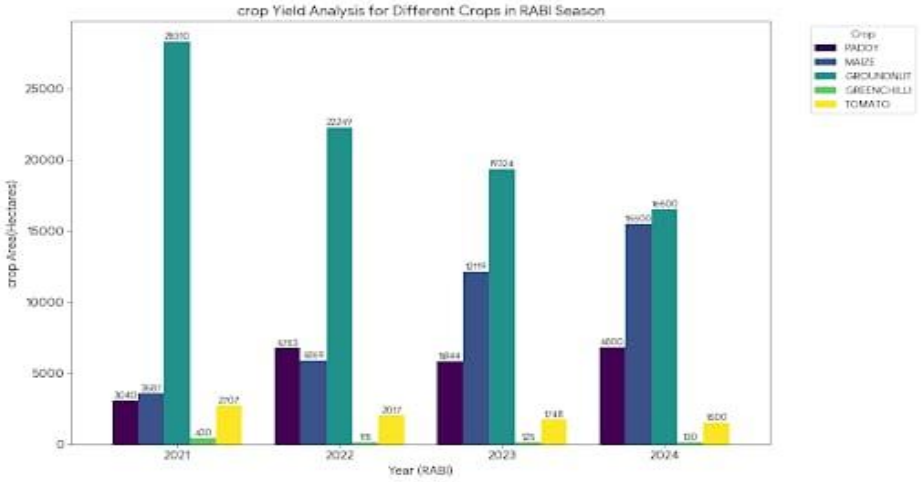

Figure 4. Rabi Season Crop Area 2021-2024

E) Crop Performance of Major Crops in Kharif Season (2025)

Kharif Season (2025): Out of the crops, cultivation areas for all crops are expected to peak sharply. Tomato and Green Chili lead this trend, reaching projected heights of approximately 17,000 and 15,500 hectares, respectively, in these optimized zones. Paddy remains a robust staple, maintaining consistent dominance in traditional sectors like Project Canals and Tube Wells with over 10,000 hectares. Conversely, Maize and Groundnut exhibit more conservative growth, stabilizing well below the 10,000 hectare mark across most irrigation categories. This distribution suggests a strategic intensification of high-value cash crops within specifically supported and high-yield agricultural clusters.

Figure 5. Kharif Season Crop Performance 2025

F) Crop Performance of Major Crops in Rabi Season (2025)

Rabi Season: Of the crops, Groundnut is overwhelmingly dominant at well over 10,000 hectares under Project Canals and Surface Irrigation peak to peak. Tomato is the main secondary crop with about 2,800 hectares area consistently present under Surface Irrigation and Tube wells (TW) systems. In contrast to Paddy, Maize and Green Chilli, which are marginal across the season and have not exceeded the area limit of 1,500 hectares at any time. The sharp drop in Groundnut area under Tube wells indicates its high dependency on large-scale surface water projects to be viable. To this end, the chart highlights a groundnut-oriented Rabi landscape with other crops merely occupying some land.

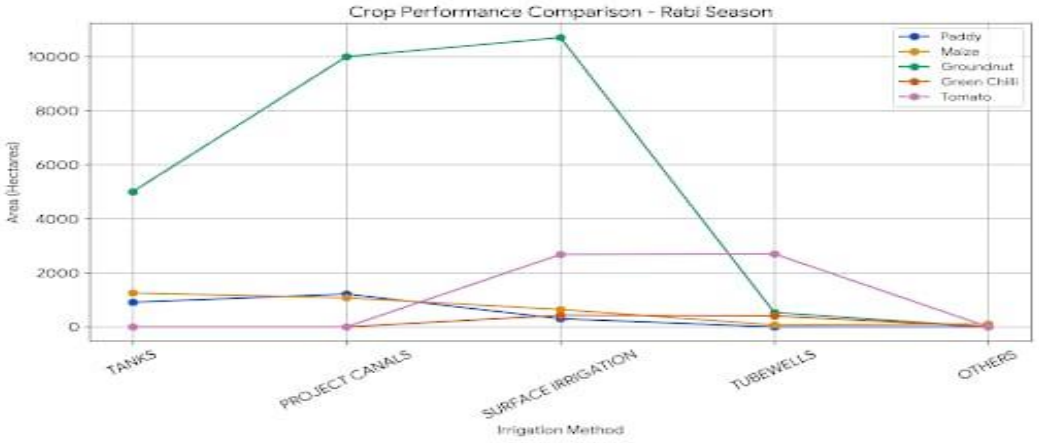

Figure 6. Rabi Season Crop Performance 2025

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G) Statistical Analysis (ANOVA Results):

The application of the Two-Way ANOVA test provided critical insights into the factors influencing agricultural output. The analysis tested the impact of the "Irrigation Source" and "Cropping Season" on the total area cultivated. The results indicate a statistically significant effect ($p < 0.05$) for irrigation methods, confirming that the type of water source, particularly tube wells versus tanks, directly determines the extent of crop coverage. However, the interaction between season and surface flow showed less significance for certain hardy crops like maize, suggesting that these crops are more resilient to seasonal water fluctuations compared to paddy.

H) Discussion of Findings:

These findings suggest that while Anantapur has made strides in diversifying its crop pattern, the vulnerability to water stress remains high. The results underscore the necessity for a shift toward micro-irrigation techniques to reduce the over-extraction of groundwater. The observation that horticultural crops are gaining traction during the Rabi season points toward a growing commercialization of agriculture in the district, which requires robust data-driven support from the National Informatics Centre to optimize water allocation schedules.

In Kharif 2024, paddy (21,606 ha) and maize (19,973 ha) were the highest grown crops, followed by tomato, chilli, and groundnut, which had the lowest cultivation area, reflecting variation in demand and suitability. The Kharif season in Anantapur witnessed a continuous rise in paddy cultivation between 2021 and 2024, with the cultivation area growing from 16,749 hectares in 2022 to 21,151 hectares in 2023, 2024 to 21,606, indicating a positive growth in the production of paddy. This stable production is largely accounted for by project canals, tube wells and other surface flows. Tomato production boomed during Rabi season between 2021 and 2022 but reduced in 2024, whereas groundnut production saw tremendous growth between the same years. The Kharif season typically provides greater yields for paddy and other specific crops, whereas Rabi season is preferable for groundnut. Tube wells dominate groundnut irrigation in both seasons, with a significant rise in Rabi. Project canals account for stable production, whereas Other surface flows contribute hardly anything.

IV. CONCLUSION

The detailed analysis on water productivity and irrigation sources from 2021 to 2025 of Anantapur district, which is mainly irrigated from groundwater, says a lot about the real way for crop productivity. It establishes that dependence on seasonal rainfall is still king in the district, but increasingly with tube wells being called the season-defining characteristic of both Kharif and Rabi seasons. The statistical results using Two-Way ANOVA show the significant effect of irrigation method on area under cultivation for major crops (paddy, maize and groundnut). Commercialization seems to be more prevalent with the cultivation of horticultural crops such as tomatoes and green chillies during the Rabi season, which are high-value but high-water crops.

Agriculture will be long-term sustainable in this arid region only if the water resources are properly managed. The results emphasize the necessity of a holistic approach that incorporates elements of classical surface water sources, like tanks and canals, with contemporary groundwater management. According to the study, in order to reduce uncertainty due to erratic weather conditions and reduce groundwater levels, farmers should use micro-irrigation and water-saving technologies. Leveraging data-driven insights of the National Informatics Centre (NIC), enabling knowledge-sharing among farmers will ensure optimal allocation of resources to improve crop yields and contribute towards food security in the district.

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