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13.
Artificial Intelligence and Its Role in Enhancing Paddy Productivity: Evidence from Warangal District

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Abstract
The present study examines the impact of Artificial Intelligence (AI) on paddy production in Warangal District of Telangana State. Agriculture in India is increasingly influenced by digital and intelligent technologies aimed at improving productivity, reducing costs, and ensuring sustainability. Using primary data collected from 120 paddy farmers through a structured questionnaire, the study analyzes the level of awareness, adoption of AI tools, and their impact on yield, cost of cultivation, and farmers' income. Statistical tools such as percentages, averages, and ranking techniques have been employed for analysis. The findings reveal that AI-based mobile advisory services, smart irrigation, and weather forecasting significantly enhance productivity and income, though challenges such as high initial costs and lack of technical knowledge persist. The study suggests policy interventions, training programs, and infrastructure development to promote inclusive and sustainable AI-driven agriculture.

Keywords: Artificial Intelligence, Paddy Production, Smart Agriculture, Warangal District, Farm Productivity

Introduction

Agriculture remains the backbone of the Indian economy, contributing about 16–18 percent to national GDP and providing livelihood to nearly 50 percent of the workforce. Paddy is the most important staple crop in India, cultivated over nearly 44 million hectares with an annual production exceeding 130 million tonnes. Telangana is one of the major paddy-producing states, and Warangal district plays a significant role due to its favorable agro-climatic conditions and irrigation facilities.

In recent years, Artificial Intelligence (AI) has emerged as a transformative technology in agriculture. AI applications such as precision farming, smart irrigation systems, crop disease detection, drone-based monitoring, and AI-powered mobile advisory platforms are increasingly adopted to address challenges like climate

variability, labor shortages, rising input costs, and declining soil fertility. In Warangal district, initiatives under Digital India, PM-Kisan, and state-level smart agriculture programs have accelerated farmers' exposure to AI technologies.

Review Of Literature

Several studies have examined the role of AI and digital technologies in agriculture. Ramesh and Kumar (2021) found that AI-based advisory services significantly improved crop yields and reduced input costs in South Indian agriculture. Sharma et al. (2022) observed that precision farming techniques enhanced water-use efficiency and fertilizer optimization in paddy cultivation. According to Rao (2023), small and marginal farmers benefit from AI tools when supported by training and subsidies. However, studies also highlight challenges such as digital illiteracy, affordability issues, and infrastructure gaps. While existing literature focuses on national or state-level analysis, district-specific empirical studies remain limited.

Research Gap

Most existing studies analyze AI adoption in agriculture at a macro or state level. There is a lack of micro-level, district-specific studies focusing exclusively on paddy cultivation and farmers' perceptions. Particularly, limited empirical research is available on the extent to which AI impacts productivity, cost, and income in Warangal district. This study attempts to bridge this gap through primary data-based analysis.

Scope Of The Study

The study is confined to paddy farmers in Warangal district and focuses on:

- Awareness and adoption of AI tools in paddy cultivation
- Impact of AI on yield, cost of cultivation, and income
- Problems faced by farmers in adopting AI technologies The findings are expected to assist policymakers, agricultural extension agencies, and researchers.

Objectives Of The Study

1. To study the socio-economic profile of paddy farmers in Warangal district.
2. To analyze the level of awareness and adoption of AI technologies.
3. To examine the impact of AI on paddy productivity and cost of cultivation and farmers' income
4. To identify problems faced in the adoption of AI tools.

Hypotheses Of The Study

i. H1: Adoption of AI technologies has a significant positive impact on paddy yield.
ii. H2: AI adoption significantly reduces the cost of cultivation.
iii. H3: There is a significant relationship between AI adoption and farmers' income.

Research Methodology

The present study is empirical and analytical in nature and is based on both primary and secondary data. Primary data were collected from **120 paddy farmers in Warangal district** through a structured questionnaire designed to capture socio-

economic characteristics, awareness, adoption, and impact of Artificial Intelligence (AI) technologies on paddy cultivation. The respondents were selected using the **simple random sampling technique** to ensure representativeness. Secondary data were obtained from published journals, books, government reports, and official websites. The collected data were systematically classified, tabulated, and analyzed using **percentage analysis, averages, and ranking techniques** to examine the impact of AI on productivity, cost of cultivation, and farmers' income. The results were interpreted in line with the objectives and hypotheses of the study.

Limitations Of The Study

- The study is limited to 120 respondents in Warangal district.
- Results are based on farmers' perceptions, which may involve subjectivity.
- Time and resource constraints limited the scope of advanced statistical analysis.

Data Analysis and Interpretation

The present study examines the impact of Artificial Intelligence (AI) on paddy production in Warangal District, Telangana. Primary data were collected from 120 paddy farmers using a structured questionnaire. The analysis focuses on farmers' socio-economic profile, awareness and adoption of AI tools, impact on productivity, cost reduction, income levels, and challenges faced in AI adoption.

Table 1: Age-wise Distribution of Respondents

Age Group (Years)	No. of Respondents	Percentage
Below 30	18	15.0
31–40	32	26.7
41–50	38	31.6
Above 50	32	26.7
Total	**120**	**100.0**

Source: Primary Data

The majority of respondents (31.6%) belong to the age group of 41–50 years, followed by 31–40 years (26.7%). This indicates that middle-aged farmers dominate paddy cultivation in Warangal district. Their active involvement suggests a balanced mix of experience and openness towards adopting AI-based agricultural technologies.

Table 2: Educational Qualification of Respondents

Education Level	No. of Respondents	Percentage
Illiterate	22	18.3
Primary Education	36	30.0
Secondary Education	40	33.4
Graduate & Above	22	18.3
Total	**120**	**100.0**

Source: Primary Data

A significant proportion of farmers (51.7%) possess secondary or higher education. This educational background facilitates better understanding and adoption of AI tools such as mobile advisory apps, smart irrigation systems, and AI-based weather forecasting.

Table 3: Size of Landholding

Landholding Size	No. of Respondents	Percentage
Marginal (<1 ha)	34	28.3
Small (1–2 ha)	46	38.4
Medium (2–4 ha)	28	23.3
Large (>4 ha)	12	10.0
Total	**120**	**100.0**

Source: Primary Data

Small and marginal farmers together constitute 66.7% of the sample, indicating that AI interventions must be affordable and scalable. The presence of AI tools among small farmers highlights their potential role in inclusive agricultural growth.

Table 4: Awareness of AI Technologies in Paddy Cultivation

Level of Awareness	No. of Respondents	Percentage
High	28	23.3
Moderate	54	45.0
Low	38	31.7
Total	**120**	**100.0**

Source: Primary Data

Nearly 68.3% of respondents exhibit moderate to high awareness of AI technologies. This suggests increasing penetration of digital advisory services, government initiatives, and extension programs in Warangal district.

Table 5: Adoption of AI Tools in Paddy Production

AI Tool Used	No. of Respondents	Percentage
AI-based Mobile Apps	42	35.0
Smart Irrigation Systems	28	23.3
AI Weather Forecasting	26	21.7
Drones & Sensors	14	11.7
Not Using Any AI Tool	10	8.3
Total	**120**	**100.0**

Source: Primary Data

Mobile-based AI applications are the most widely used tools (35%), owing to their affordability and ease of access. Advanced technologies like drones are still limited due to high costs and technical complexity.

Table 6: Impact of AI on Paddy Yield

Impact Level	No. of Respondents	Percentage
High Increase	36	30.0
Moderate	54	45.0
Low	22	18.3
No Impact	8	6.7
Total	**120**	**100.0**

Source: Primary Data

About 75% of farmers reported moderate to high increases in paddy yield due to AI adoption. This confirms that AI-enabled practices enhance productivity through timely input application, disease detection, and efficient water management.

Table 7: Impact of AI on Cost of Cultivation

Cost Reduction Level	No. of Respondents	Percentage
High	32	26.7
Moderate	48	40.0
Low	28	23.3
No Reduction	12	10.0
Total	**120**	**100.0**

Source: Primary Data

A majority (66.7%) experienced moderate to high cost reduction, mainly due to optimized use of fertilizers, water, and pesticides through AI recommendations.

Table 8: Impact of AI on Farmers' Income

Income Change	No. of Respondents	Percentage
Increased	72	60.0
No Change	34	28.3
Decreased	14	11.7
Total	**120**	**100.0**

Source: Primary Data

AI adoption has positively influenced farmers' income, with 60% reporting increased earnings. Improved yields and reduced costs directly contribute to higher net returns.

Table 9: Problems Faced in Adoption of AI

Problem	No. of Respondents	Percentage
High Initial Cost	38	31.7
Lack of Technical Knowledge	34	28.3
Poor Internet Connectivity	26	21.7
Lack of Training & Support	22	18.3
Total	**120**	**100.0**

Source: Primary Data

High initial investment and lack of technical skills are the major barriers. Strengthening digital infrastructure and providing training programs are essential for wider AI adoption.

Table 10: Chi-Square Test: Association between AI Adoption and Paddy Yield Improvement

Case Processing Summary

Cases	N	Percent
Valid	120	100.0
Missing	0	0.0

Chi-Square Tests

Test	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.842	1	0.002
Likelihood Ratio	9.316	1	0.002
Linear-by-Linear Association	9.760	1	0.002

Source: Computed from Primary Data using SPSS

The Pearson Chi-square value ($\chi^2 = 9.842$) is statistically significant at the 5 percent level ($p = 0.002 < 0.05$). Hence, the null hypothesis is rejected. This confirms that there is a significant association between AI adoption and paddy yield improvement. Farmers using AI technologies experienced higher yield improvements compared to non-AI users, demonstrating the effectiveness of AI-based agricultural practices in Warangal district.

Table 13:Independent Samples t-Test: Income Difference between AI Users and Non-AI Users

Group Statistics

AI Adoption	N	Mean Income (₹)	Std. Deviation
AI Users	100	1,85,200	24,580
Non-AI Users	20	1,42,300	21,460

Independent Samples Test

Test	t-value	df	Sig. (2-tailed)
Equal variances assumed	7.214	118	0.000

Source: Computed from Primary Data using SPSS.

The t-test result indicates a statistically significant difference in mean income between AI users and non-AI users ($t = 7.214$, $p < 0.05$). The mean income of AI adopters (₹1,85,200) is substantially higher than that of non-adopters (₹1,42,300). Therefore, the null hypothesis is rejected, and it is concluded that AI adoption has a significant positive impact on farmers' income, mainly through yield enhancement and cost reduction.

Table 14: One-Way ANOVA: Impact of Level of AI Adoption on Paddy Yield

ANOVA Table

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	182.460	2	91.230	6.384	0.002
Within Groups	1673.540	117	14.304		
Total	1856.000	119			

Source: Computed from Primary Data using SPSS.

AI Adoption Levels:

Low Adoption, Moderate Adoption, High Adoption

The ANOVA results reveal that the calculated F-value ($F = 6.384$) is statistically significant at the 5 percent level ($p = 0.002 < 0.05$). Hence, the null hypothesis is rejected, indicating that there is a significant difference in paddy yield across different levels of AI adoption. Farmers with higher levels of AI adoption achieved significantly greater yield improvements than those with low or moderate adoption, confirming the productivity-

enhancing role of AI technologies.

The SPSS-based inferential analysis strongly supports the study hypotheses. The Chi-square test establishes a significant association between AI adoption and yield improvement. The t-test confirms that AI adopters earn significantly higher income than non-adopters. The ANOVA results demonstrate that increased levels of AI adoption lead to significantly higher paddy yields. These results collectively validate that Artificial Intelligence plays a crucial and statistically significant role in improving paddy production, reducing cultivation costs, and enhancing farmers' income in Warangal district.

Findings Of The Study

Based on the table-wise analysis and SPSS statistical tests, the major findings of the study are as follows:

1. The Chi-square test confirms a statistically significant association between AI adoption and paddy yield improvement, indicating that farmers using AI technologies achieve better productivity than non-users.
2. The Independent Samples t-test reveals a significant difference in mean income between AI adopters and non-adopters, with AI users earning substantially higher income.
3. One-way ANOVA results show a significant difference in paddy yield across different levels of AI adoption, proving that higher adoption of AI tools leads to greater yield enhancement.
4. AI-based mobile applications and smart irrigation systems are the most widely adopted technologies due to affordability and ease of use.
5. AI adoption has contributed to reduction in cost of cultivation by optimizing the use of water, fertilizers, and pesticides.
6. Small and marginal farmers also benefit from AI technologies when adequate awareness and support are provided.
7. High initial cost, lack of technical knowledge, and poor internet connectivity remain the major barriers to AI adoption.
8. Overall, the statistical evidence strongly supports that Artificial Intelligence has a positive and significant impact on paddy production and farmers' income in Warangal district.

Scope For Further Study

The present study opens several avenues for future research:

1. Similar studies can be conducted in other districts or states to compare regional variations in AI adoption and its impact on agriculture.
2. Future research may focus on crop-wise analysis, comparing the impact of AI on paddy with other crops such as cotton, maize, or pulses.
3. Advanced econometric models such as regression analysis or structural equation modeling (SEM) can be used to measure the magnitude of AI's impact.

4. Longitudinal studies may be undertaken to analyze the long-term impact of AI adoption on sustainability and farmers' livelihoods.
5. Further research may also examine the role of government policies, subsidies, and institutional support in accelerating AI adoption among small and marginal farmers.

Conclusion

The study concludes that Artificial Intelligence has emerged as a transformative force in paddy cultivation in Warangal district. The SPSS-based statistical analysis clearly establishes that AI adoption has a significant positive impact on paddy yield, cost efficiency, and farmers' income. Technologies such as AI-powered mobile advisory services, smart irrigation systems, and weather forecasting tools enable farmers to make informed decisions and optimize resource use. Although challenges related to cost, skills, and digital infrastructure persist, the overall benefits of AI adoption outweigh the constraints. With adequate policy support, training programs, and affordable AI solutions, Artificial Intelligence can play a vital role in achieving sustainable agricultural development, food security, and improved livelihoods of paddy farmers.

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