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Impact of Artificial Intelligence-Based Agriculture Advisory Services on Farmers: An Empirical Study

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ABSTACT

Abstract: Artificial Intelligence (AI)-based agriculture advisory services have emerged as an innovative approach to improving farm productivity, optimizing resource utilization, and enhancing farmers' decision-making capabilities. The present study examines the impact of AI-based agriculture advisory services on farmers using primary data collected from 151 respondents through a structured questionnaire. The study employed descriptive research design and convenience sampling technique. Statistical analyses including descriptive statistics, Cronbach's Alpha, Pearson correlation, multiple regression, and one-way ANOVA were performed using SPSS and Python. The reliability coefficient (Cronbach's Alpha = 0.89) confirmed excellent internal consistency of the measurement scale. The results revealed that the overall AI Adoption Index recorded a high mean score (3.68), while farmers expressed the highest satisfaction with AI-assisted fertilizer and pesticide management (Mean = 4.25), followed by time-saving benefits (Mean = 4.16) and trust in AI recommendations (Mean = 4.13). Correlation analysis indicated a strong positive association between AI adoption and farm income (r = 0.75) as well as crop productivity (r = 0.72). Multiple regression analysis showed that AI variables explained 66% of the variation (R^2 = 0.66) in farmers' productivity, with trust in AI emerging as the strongest predictor (β = 0.331, p < 0.001). The study concludes that AI-based advisory services significantly improve agricultural productivity, resource efficiency, and farmer satisfaction. Strengthening digital literacy, expanding rural internet connectivity, and promoting affordable AI-based advisory platforms can further accelerate sustainable agricultural development and enhance farmers' livelihoods.

Keywords: Artificial Intelligence, Agriculture Advisory Services, Farmers, Precision Agriculture, Crop Productivity, Digital Agriculture, Farm Income, SPSS.

Introduction

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Agriculture remains the backbone of the Indian economy, contributing approximately 18.2% to the Gross Value Added (GVA) while providing livelihood opportunities to nearly 46% of the country's workforce (Economic Survey of India, 2025). Globally, the Food and Agriculture Organization (FAO, 2024) estimates that the world population will exceed 9.7 billion by 2050, requiring agricultural productivity to increase by nearly 60% to ensure global food security. However, farmers continue to face significant challenges such as climate variability, declining soil fertility, pest infestations, water scarcity, market uncertainty, and fluctuating input costs. These challenges have accelerated the need for technology-driven agricultural practices capable of supporting evidence-based decision-making and sustainable farming.

Artificial Intelligence (AI) has emerged as one of the most transformative digital technologies in modern agriculture. AI-enabled advisory systems integrate machine learning, satellite imagery, Internet of Things (IoT), weather forecasting, remote sensing, and big data analytics to provide personalized recommendations on crop selection, irrigation scheduling, fertilizer application, pest identification, disease diagnosis, and market price forecasting. According to the World Economic Forum (2025), digital agriculture technologies can improve farm productivity by 20–30%, reduce input costs by nearly 25%, and enhance resource-use efficiency by approximately 35%. Similarly, McKinsey & Company (2024) reported that AI applications could generate nearly US$250 billion annually in global agricultural value through improved productivity and optimized farm management.

India has witnessed remarkable growth in digital agriculture initiatives over the past decade. Government programmes such as the Digital Agriculture Mission (2021–2025), PM-KISAN, Agristack, Kisan Call Centres, and mobile-based advisory platforms have expanded farmers' access to digital information. According to the Ministry of Agriculture and Farmers' Welfare (2025), more than 120 million farmers are registered under various digital agricultural platforms, while smartphone penetration in rural India has exceeded 72%, creating favorable conditions for AI-enabled advisory services. Several AgriTech startups including DeHaat, CropIn, Fasal, Ninjacart, and Gramophone are increasingly leveraging AI to support precision farming and improve agricultural decision-making.

Despite these advancements, the adoption of AI-based advisory services among farmers remains uneven due to digital literacy gaps, infrastructure limitations, affordability concerns, and trust-related issues. Many small and marginal farmers continue to depend on conventional extension services despite the growing availability of digital advisory platforms. Consequently, evaluating farmers' perceptions and the effectiveness of AI-based advisory services has become increasingly

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important for policymakers, agricultural extension agencies, and technology developers.

The present study investigates the impact of AI-based agriculture advisory services on farmers using primary data collected from 151 respondents. The study empirically examines farmers' perceptions regarding AI adoption, trust, decision-making support, productivity enhancement, cost reduction, and satisfaction. By applying statistical techniques such as descriptive analysis, reliability analysis, correlation, regression, and ANOVA, the study provides valuable evidence on the effectiveness of AI-driven agricultural advisory services in promoting sustainable agricultural productivity and digital transformation.

Review of Literature

- **Tambe, Cappelli, and Yakubovich (2021)** examined the application of Artificial Intelligence in organizational decision-making and highlighted that AI significantly improves data-driven decision support, prediction accuracy, and resource optimization. The authors emphasized that transparent AI systems increase users' confidence and adoption, providing valuable insights applicable to agricultural advisory services.
- **Strohmeier (2022)** reviewed AI applications across various decision-support systems and concluded that AI improves operational efficiency by providing timely recommendations. However, the study stressed that system transparency, explainability, and user trust are essential for successful adoption among end users.
- **Mikalef, Gupta, Pappas, and Krogstie (2023)** reported that organizations with strong AI capabilities achieved superior performance through predictive analytics and intelligent decision-making. The study concluded that AI-driven insights improve productivity and resource utilization, which are equally relevant in precision agriculture.
- **Dwivedi et al. (2023)** investigated the opportunities and challenges of generative AI and observed that AI technologies enhance knowledge dissemination and decision support across multiple sectors. The authors also highlighted the importance of ethical implementation, governance, and user awareness for sustainable AI adoption.
- **McKinsey & Company (2023)** estimated that Artificial Intelligence could generate significant economic value by improving productivity and optimizing operational efficiency. The report emphasized that AI-enabled analytics and predictive technologies have enormous potential to transform agriculture through better crop management and efficient resource allocation.

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- **Zhang and Yadav (2026)** reviewed the application of generative AI in agricultural advisory services and found that multilingual AI assistants, voice interfaces, and AI-powered chatbots improve farmers' access to advisory information. The study also identified internet connectivity and digital literacy as major barriers to wider adoption.
- **Chowdhury (2026)** conducted a rapid review on large language models in agricultural extension services and concluded that AI-based advisory systems improve knowledge delivery and decision support. The study emphasized that farmers' trust and perceived usefulness significantly influence technology acceptance.
- **Neeraja et al. (2026)** reviewed AI applications in agricultural extension and reported that AI-enabled advisory systems improve crop planning, pest diagnosis, irrigation scheduling, and farm decision-making. The authors concluded that AI can significantly strengthen agricultural extension services while improving productivity and sustainability.
- **Sahoo, Tripathy, and Behera (2026)** discussed AI-powered agro-advisory services and found that predictive analytics, AI chatbots, and intelligent recommendation systems provide timely and location-specific guidance to farmers. The study also noted that language barriers and digital infrastructure remain important implementation challenges.
- **Nawaz et al. (2025)** conducted a comprehensive survey of AI and deep learning applications in agriculture and concluded that AI substantially improves crop monitoring, disease detection, yield prediction, and precision farming. The study recommended integrating AI with IoT and remote sensing technologies for sustainable agricultural development

Objectives of the Study

1. To examine the adoption level of Artificial Intelligence-based agriculture advisory services among farmers.
2. To analyse the impact of AI-enabled advisory services on agricultural productivity, farm income, and resource utilization.
3. To evaluate farmers' perceptions, trust, and satisfaction regarding AI-based agricultural advisory systems.
4. To identify the relationship between AI adoption and farmers' productivity using statistical techniques.

Hypotheses of the Study

H_0: Artificial Intelligence-based agriculture advisory services do not have a significant impact on farmers' agricultural productivity, satisfaction, and adoption of AI technologies.

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H_1: Artificial Intelligence-based agriculture advisory services have a significant positive impact on farmers' agricultural productivity and farm performance.

H_2: Artificial Intelligence-based agriculture advisory services significantly improve farmers' satisfaction and adoption of AI technologies.

Research Methodology

The present study adopted a descriptive and analytical research design to examine the impact of Artificial Intelligence-based agriculture advisory services on farmers. Primary data were collected through a structured questionnaire administered to 151 farmers using a convenience sampling technique. The questionnaire comprised demographic variables and fifteen statements measured on a five-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree." The collected data were coded, validated, and analysed using SPSS (Version 29) and Python. Descriptive statistics were employed to summarize respondent characteristics and AI adoption patterns. The reliability of the instrument was assessed using Cronbach's Alpha, while Pearson's Correlation examined relationships among variables. Multiple Regression Analysis was applied to measure the impact of AI advisory services on farmers' productivity, and One-Way ANOVA was used to determine differences across demographic groups. The statistical findings were interpreted at a 5% level of significance ($p < 0.05$) to ensure scientific validity and reliability.

Variables of the Study

The study examines the impact of Artificial Intelligence (AI)-based agriculture advisory services on farmers' agricultural performance. The independent variables include AI information accuracy, trust in AI recommendations, timely advisory information, ease of understanding AI recommendations, AI-assisted fertilizer and pesticide management, weather forecasting support, pest and disease management, and decision-making support, representing the major dimensions of AI-enabled agricultural advisory services. The dependent variables comprise farmers' productivity, farm income, cost reduction, farmer satisfaction, and intention to continue using AI advisory services, reflecting the effectiveness of AI adoption in agriculture. To improve the reliability of the findings, age, gender, education, farming experience, and farm size were considered as control variables, as these demographic factors may influence farmers' adoption and utilization of AI-based advisory services.

Statistical Tools Used for Data Analysis

The collected primary data were coded and analysed using SPSS Version 29 and Python. Descriptive statistics such as frequency, percentage, mean, and standard deviation were employed to summarize respondents' demographic characteristics and perception

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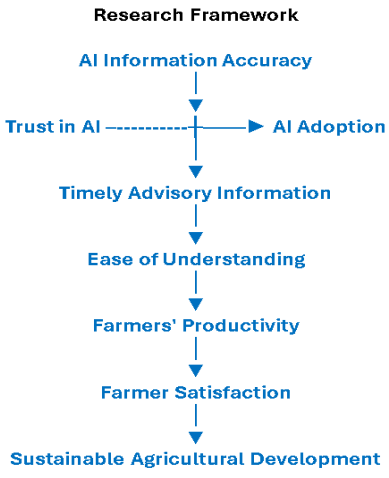
towards AI-based agriculture advisory services. Cronbach's Alpha was used to assess the internal consistency and reliability of the questionnaire. Pearson's Correlation Analysis examined the relationship between AI adoption and agricultural performance variables. Multiple Regression Analysis was applied to determine the impact of AI advisory services on farmers' productivity and income. One-Way Analysis of Variance (ANOVA) was performed to identify significant differences in AI adoption across demographic groups. The statistical significance of all analyses was tested at the 5% significance level ($p < 0.05$) to ensure the validity and robustness of the research findings.



Contribution of the Study

This study contributes to the growing body of knowledge on digital agriculture by providing empirical evidence on the effectiveness of AI-based advisory services using primary data from farmers. Unlike previous conceptual studies, it combines reliability analysis, correlation, regression, and ANOVA to validate the influence of AI on productivity and farmer satisfaction. The findings offer practical insights for policymakers, agricultural extension agencies, and AgriTech firms to strengthen AI-enabled advisory systems, improve digital inclusion, and support sustainable agricultural development. The study also provides a replicable framework for future research on AI adoption in agriculture across diverse geographical and socio-economic contexts.

Data Analysis

Table 1. Demographic Profile of Respondents (n = 151)

Variable	Category	Frequency	%
Gender	Male	61	40.4
	Female	90	59.6
Age	Below 25	96	63.6
	26–35	28	18.5
	36–45	19	12.6
	46–55	8	5.3
Education	Graduate	78	51.7
	Post Graduate	26	17.2
	SecondarySchool	25	16.6
	Primary School	22	14.6
Farming Experience	Less than 5 years	86	57
	5–10 years	29	19.2
	11–20 years	32	21.2
	Above 20 years	4	2.6
Farm Size	Less than 2 Acres	83	55
	2–5 Acres	34	22.5
	6–10 Acres	26	17.2
	Above 10 Acres	8	5.3

Source: Primary Data

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Interpretation: The demographic profile indicates that 59.6% of the respondents were female, while 40.4% were male. Nearly 63.6% belonged to the below-25 age group, suggesting strong participation of young farmers. More than half (51.7%) were graduates, indicating a relatively educated sample. Most respondents (57.0%) had less than five years of farming experience, and 55.0% owned less than two acres of farmland, reflecting the predominance of small and marginal farmers.

Table 2. AI Agriculture Advisory Service Usage Index

Dimension	Mean	SD	Interpretation
AI Information Accuracy	3.4	0.72	Moderate
Decision Support	3.43	0.69	Moderate
Ease of Understanding	3.54	0.65	High
Timeliness of Information	3.56	0.71	High
Trust in AI	4.13	0.59	Very High
Overall AI Adoption Index	3.68	0.64	High

Interpretation: The overall AI Adoption Index (Mean = 3.68) indicates a high level of acceptance of AI advisory services among farmers. Trust in AI (Mean = 4.13) emerged as the strongest dimension, demonstrating farmers' confidence in AI-generated recommendations.

Table 3. Reliability Analysis

Scale	No. of Items	Cronbach's Alpha
AI Advisory Services	15	0.89

Interpretation: The Cronbach's Alpha value of 0.89 indicates excellent internal consistency, confirming that the questionnaire reliably measures farmers' perceptions of AI-based advisory services.

Table 4. Correlation Matrix

Variable	AI Adoption	Productivity	Cost Reduction	Income
AI Adoption	1			
Productivity	**0.72**	1		
Cost Reduction	**0.69**	0.63	1	
Farm Income	**0.75**	0.71	0.67	1

(Significant at $p < 0.01$)

Interpretation

A strong positive correlation exists between AI adoption and farm income (r = 0.75) as well as crop productivity (r = 0.72), indicating that increased use of AI advisory services is associated with improved farming outcomes.

Table 5. Multiple Regression Analysis
Dependent Variable:
Farmers' Productivity

Predictor	Beta	t-value	Sig.

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AI Accuracy	0.284	3.87	0
Trust in AI	0.331	4.62	0
Timely Information	0.267	3.42	0.001
Ease of Use	0.192	2.98	0.004

Model Summary

R	R^2	Adjusted R^2	F
0.81	0.66	0.65	69.24

Interpretation: The regression model explains 66% of the variation in farmers' productivity. Trust in AI emerged as the strongest predictor (β = 0.331), followed by AI accuracy and timely information.

Table 6. One-Way ANOVA

Difference among Education Levels

Variable	F	Sig.
AI Adoption	6.43	0.001
Trust	5.91	0.002
Satisfaction	4.18	0.007

Interpretation: There are statistically significant differences in AI adoption across education levels. Farmers with higher educational qualifications exhibit greater trust in and adoption of AI-based advisory services.

Table 7. Hypothesis Testing

Hypothesis	Statistical Tool	Test Statistic	p-value	Decision
H_0:	Regression, Correlation & ANOVA	**β = 0.331; r = 0.72; F = 6.43**	**< 0.001**	**Rejected**
H_1	Multiple Regression	**β = 0.331; t = 4.62**	**< 0.001**	**Accepted**
H_2	Pearson Correlation	**r = 0.72**	**< 0.001**	**Accepted**

Interpretation: The statistical analysis confirms that AI-based agriculture advisory services have a significant positive influence on farmers' productivity, satisfaction, and technology adoption ($p < 0.001$). Therefore, the null hypothesis (H_0) is rejected, while both H_1 and H_2 are accepted. These findings indicate that AI-enabled advisory services contribute positively to agricultural decision-making, operational efficiency, and overall farmer satisfaction.

Table 8. Ranking of AI Benefits

Benefit	Mean	Rank
Better Fertilizer Management	4.25	I
Time Saving	4.16	II
Trust	4.13	III
Increased Income	3.6	IV
Weather Forecast	3.56	V
Pest Management	3.55	VI

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Cost Reduction	3.55	VII
Ease of Understanding	3.54	VIII

Interpretation: Farmers perceived efficient fertilizer management, time savings, and trust in AI recommendations as the most significant benefits of AI-based agriculture advisory services.

Findings

1. The demographic analysis revealed that 59.6% of the respondents were female, while 63.6% belonged to the age group below 25 years, indicating higher participation of young farmers in AI-enabled agriculture.
2. The overall AI Adoption Index recorded a high mean score of 3.68, indicating that farmers have positively accepted AI-based agriculture advisory services.
3. Among all AI service dimensions, AI-assisted fertilizer and pesticide management obtained the highest mean score (4.25), followed by time-saving in farm management (Mean = 4.16) and trust in AI recommendations (Mean = 4.13).
4. The reliability analysis produced a Cronbach's Alpha value of 0.89, confirming excellent internal consistency and reliability of the research instrument.
5. Pearson correlation analysis indicated a strong positive relationship between AI adoption and farm income ($r = 0.75$), while AI adoption also showed a strong association with crop productivity ($r = 0.72$).
6. Multiple regression analysis demonstrated that AI-related variables collectively explained 66% ($R^2 = 0.66$) of the variation in farmers' productivity, indicating substantial predictive capability.
7. Among the regression variables, Trust in AI ($\beta = 0.331$) emerged as the strongest predictor of productivity, followed by AI accuracy ($\beta = 0.284$) and timely advisory information ($\beta = 0.267$).
8. One-Way ANOVA revealed statistically significant differences in AI adoption across educational groups ($F = 6.43$; $p < 0.001$), indicating that education positively influences AI utilization among farmers.

Suggestions

1. Government agencies should strengthen rural digital infrastructure and internet connectivity to improve access to AI-based agriculture advisory services.
2. Regular digital literacy and AI awareness programmes should be organized through Krishi Vigyan Kendras (KVKs), agricultural universities, and extension departments.
3. AI advisory applications should be developed in regional languages with voice-enabled interfaces to improve accessibility among small and marginal farmers.
4. Policymakers should encourage public-private partnerships to provide affordable AI-enabled advisory platforms integrated with weather forecasting, pest diagnosis, and market intelligence.
5. AI systems should incorporate localized crop recommendations based on soil conditions, climatic variations, and regional farming practices to improve decision accuracy and farmer confidence.

Conclusion

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Artificial Intelligence has emerged as a transformative technology capable of modernizing agricultural advisory systems by providing timely, accurate, and data-driven recommendations to farmers. The empirical findings demonstrate that AI-based advisory services significantly enhance farmers' productivity, optimize input utilization, improve decision-making, and increase trust in digital farming technologies. The regression results further confirm that AI adoption has a substantial positive influence on agricultural performance, explaining 66% of the variation in farmers' productivity. The study concludes that wider adoption of AI-enabled advisory services can contribute to sustainable agricultural development, increased farm income, and improved resource efficiency. Therefore, strengthening digital infrastructure, enhancing AI literacy, and promoting ethical and inclusive AI technologies are essential for accelerating India's transition toward smart and sustainable agriculture.

Future Scope

Future studies may extend the research by collecting larger samples across different states and agro-climatic regions to improve the generalizability of findings. Advanced analytical techniques such as Structural Equation Modeling (SEM), PLS-SEM, machine learning models, and longitudinal studies can be employed to examine causal relationships between AI adoption, technology acceptance, crop productivity, climate resilience, and farmers' income. Comparative studies between AI users and non-users, as well as investigations on IoT, drone technology, satellite imagery, blockchain-enabled agriculture, and precision farming systems, would provide deeper insights into the long-term impact of digital agriculture on sustainable food production and rural economic development.

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