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AI-Driven Smart Agriculture and Food Security in Developing Countries: A Comparative Perspective

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Abstract- Agriculture remains a cornerstone of economic development and food security in many developing countries. However, the sector continues to face challenges such as climate change, declining natural resources, labour shortages, and increasing production costs. Recent advances in artificial intelligence (AI) and smart agriculture provide new opportunities to improve agricultural productivity, optimize resource use, and strengthen food security. This study examines the role of AI-driven smart agriculture in enhancing food security through a comparative analysis of India, China, Brazil, Vietnam, Kenya, and Indonesia. The findings reveal considerable differences in AI readiness and the adoption of smart agricultural technologies among the countries. Nations with stronger digital infrastructure and higher AI readiness demonstrate greater adoption of precision farming practices and better food security outcomes. The study concludes that expanding digital infrastructure, improving farmers' access to AI-based technologies, strengthening technical capacity, and encouraging collaboration among governments, research institutions, and agritech firms are essential for achieving sustainable agricultural development and improving food security in developing countries. The novelty of this study lies in integrating AI readiness, digital infrastructure, precision farming adoption, and food security into a comparative analysis of six developing countries using 2024 secondary data.

Keywords- Artificial Intelligence, Smart Agriculture, Food Security, Sustainable Agriculture.

I. Introduction

India is the most populous country of the world and has changing socio- political demographic patterns that have been drawing global attention in recent years. Agriculture plays a vital role in the economies of developing countries by ensuring food security, generating employment, and supporting rural livelihoods. However, the sector is increasingly challenged by climate change, resource scarcity, declining productivity, and rising production costs. These issues have created a need for innovative technologies that can improve agricultural efficiency while promoting sustainability.

Artificial Intelligence (AI) has emerged as a key driver of smart agriculture by enabling precision farming, real-time crop monitoring, weather forecasting, pest detection, and data-driven decision-making. The adoption of AI technologies helps optimize the use of water, fertilizers, and other agricultural inputs, thereby enhancing productivity and strengthening food security. Despite these benefits, the level of AI adoption varies considerably across developing countries due to differences in digital infrastructure, technological readiness, and policy support.

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Against this background, the present study compares India with selected developing countries to examine the relationship between AI-driven smart agriculture and food security. The findings provide insights into the role of digital innovation in promoting sustainable agricultural development and offer policy recommendations for accelerating AI adoption in agriculture.

The study is also aligned with the United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), which aims to end hunger and promote sustainable agriculture; SDG 9 (Industry, Innovation and Infrastructure), which encourages technological innovation and digital infrastructure; SDG 12 (Responsible Consumption and Production), which promotes the efficient use of natural resources; and SDG 13 (Climate Action), which emphasizes climate-resilient agricultural practices. By examining the role of AI-driven smart agriculture in improving food security, the study contributes to the broader global agenda of sustainable development.

II. Review of Literature

Jha and Kumar (2023) explored the application of artificial intelligence in agriculture and concluded that AI-based technologies have the potential to improve farming efficiency through precision agriculture, crop monitoring, and predictive decision support. Their study highlighted that the effective use of AI can reduce input costs, increase productivity, and encourage sustainable farming practices.

The Food and Agriculture Organization (FAO, 2024) emphasized that digital technologies are transforming agricultural systems by improving resource management, enhancing crop productivity, and supporting climate-resilient farming. The report also stressed that expanding digital infrastructure and strengthening farmers' technical skills are essential for the wider adoption of smart agricultural technologies.

According to the Government AI Readiness Index published by Oxford Insights (2024), countries with well-developed digital infrastructure, supportive public policies, and strong institutional capacity are more likely to successfully integrate AI into different sectors, including agriculture. The report suggests that improving AI readiness can accelerate agricultural innovation and contribute to long-term food security and sustainable development.

Conceptual Framework

The present study is based on the premise that improvements in digital infrastructure create an enabling environment for artificial intelligence adoption in agriculture. Strong digital connectivity enhances a country's AI readiness, which facilitates the adoption of precision farming technologies such as smart irrigation, drones, sensors, and data-driven advisory systems. These technologies improve agricultural productivity by optimizing resource utilization, increasing crop yields, and reducing production costs. Improved agricultural productivity ultimately contributes to enhanced food security and sustainable agricultural development. Based on this framework, the study examines the relationship between digital infrastructure, AI readiness, precision farming adoption, and food security among selected developing countries.

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Research Gap

Although previous studies have highlighted the importance of artificial intelligence in enhancing agricultural productivity and promoting sustainable farming, most have focused on individual countries or specific AI applications. There is limited comparative research that examines how AI readiness and smart agricultural practices influence food security across developing countries. Furthermore, recent cross-country evidence using 2024 data is scarce. To bridge this gap, the present study compares India with China, Brazil, Vietnam, Kenya, and Indonesia to assess the role of AI-driven smart agriculture in improving food security and supporting sustainable agricultural development.

Novelty of the Study

The novelty of this study lies in its comparative analysis of AI-driven smart agriculture and food security across six developing countries—India, China, Brazil, Vietnam, Kenya, and Indonesia-using the most recent 2024 secondary data from internationally recognized databases. Unlike previous studies that primarily focus on a single country or specific AI applications, this study integrates digital infrastructure, AI readiness, precision farming adoption, sustainable agricultural practices, and food security within a single analytical framework. The findings provide evidence-based policy insights for promoting sustainable agricultural development and strengthening food security in developing countries.

Objectives of the Study

1. To assess and compare the agricultural characteristics of India and selected developing countries.
2. To evaluate the extent of AI readiness and the adoption of smart agriculture technologies in the selected countries.
3. To examine the association between AI readiness, precision farming practices, and food security outcomes.
4. To recommend policy strategies for strengthening AI-driven smart agriculture and enhancing food security in developing countries.

III. Research Methodology

This study adopts a comparative descriptive research design to examine the role of AI-driven smart agriculture in enhancing food security across six developing countries: India, China, Brazil, Vietnam, Kenya, and Indonesia. These countries were selected because they represent different levels of agricultural dependence, digital infrastructure, AI readiness, and technological adoption, enabling meaningful cross-country comparison.

The study is based entirely on secondary data for the year 2024, collected from internationally recognized sources, including the World Bank, FAOSTAT, ILOSTAT, the International Telecommunication Union (ITU), Oxford Insights Government AI Readiness Index, and the Global Food Security Index. The selected variables include agriculture's share in GDP, agricultural employment, internet penetration, AI readiness, precision farming adoption, irrigation efficiency, fertilizer use efficiency, and the Food Security Index. These indicators were chosen because they collectively represent agricultural performance, digital readiness, AI adoption, sustainable resource management, and food security.

Table 1.
Description of Variables Used in the Study

Variable	Indicator
Agriculture	Agriculture (% of GDP), Agricultural Employment (%)
Digital Infrastructure	Internet Users (%)
AI Readiness	Government AI Readiness Index
Smart Agriculture	Precision Farming Adoption (%)
Sustainable Agriculture	Irrigation Efficiency (%), Fertilizer Use Efficiency (%)
Food Security	Global Food Security Index

Source: Compiled by the author based on World Bank (2024), FAOSTAT (2024), ILOSTAT (2024), International Telecommunication Union (ITU) (2024), Oxford Insights (2024), and Economist Impact (2024).

To analyse the data, the study employs descriptive statistics (mean, percentage, and comparative analysis) to summarize and compare the characteristics of the selected countries. In addition, Pearson correlation analysis is used to examine the relationships among digital infrastructure, AI readiness, precision farming adoption, and food security. These analytical techniques are appropriate for identifying patterns, variations, and associations among the selected variables and for drawing meaningful policy implications.

The study employs purposive sampling to select six developing countries-India, China, Brazil, Vietnam, Kenya, and Indonesia. These countries were chosen because they represent diverse levels of agricultural dependence, digital infrastructure, AI readiness, precision farming adoption, and food security. They also represent different geographical regions of Asia, Africa, and Latin America, providing a broad comparative perspective on the role of AI-driven smart agriculture in developing economies. The diversity among the selected countries enables a meaningful analysis of how variations in technological readiness and agricultural development influence food security and sustainable agricultural development.

Table 2.
Rationale for the Selection of Countries

Country	Rationale for Selection
India	Major developing agricultural economy and the primary focus of the study, with increasing adoption of AI in agriculture.
China	Leader among developing countries in AI readiness, digital infrastructure, and precision farming adoption.

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Country	Rationale for Selection
Brazil	One of the world's largest agricultural producers with extensive use of precision agriculture technologies.
Vietnam	Emerging economy with rapid growth in digital agriculture and agricultural modernization.
Kenya	Represents Sub-Saharan Africa, characterized by high agricultural dependence and relatively low AI readiness.
Indonesia	Large developing agricultural economy undergoing digital transformation and expanding smart farming initiatives.

Source: Compiled by the author based on World Bank (2024), FAOSTAT (2024), Oxford Insights (2024), ITU (2024), and national agricultural reports.

Table 3.
Analysis of Agricultural Profile and Food Security

Indicator	Key Finding	Link to Food Security
Agriculture (% of GDP)	Kenya (21.0%) and India (16.5%) have the highest dependence on agriculture.	Agriculture remains the primary source of food production and rural livelihoods.
Agriculture Employment (%)	Kenya (54%) and India (43%) employ the largest agricultural workforce.	A larger agricultural workforce supports food production but requires technological improvements for higher productivity.
Internet Users (%)	Brazil (84%), Vietnam (79%), and China (78%) have better digital connectivity than Kenya (42%).	Higher internet access enables AI-based farming, leading to improved agricultural efficiency and food security.

Source: Compiled by the author using data from World Bank (2024), FAOSTAT (2024), ILOSTAT (2024), and International Telecommunication Union (ITU) (2024).

This presents the agricultural profile of the selected developing countries and its relevance to food security. Kenya and India exhibit the highest dependence on agriculture in terms of both GDP contribution and employment, highlighting the sector's significant role in supporting livelihoods and ensuring food availability. In contrast, China and Brazil have lower agricultural dependence, reflecting more diversified economic structures. The data also reveal considerable variation in internet penetration, with Brazil, Vietnam, and China recording higher levels of digital connectivity than Kenya. Improved internet access facilitates the adoption of AI-driven technologies such as precision farming, digital advisory services, and smart irrigation, which enhance agricultural productivity, optimize resource use, and ultimately contribute to improved food security.

Overall, the findings indicate that stronger digital infrastructure provides the foundation for AI-enabled agricultural technologies, which can improve agricultural productivity and contribute to enhanced food security in developing countries.

Table 4.
Analysis of AI Adoption and Food Security

Indicator	Key Finding	Link to Food Security
AI Readiness Index	China (83) has the highest AI readiness, while Kenya (47) has the lowest.	Greater AI readiness supports the adoption of smart farming technologies that improve food production.
Precision Farming Adoption	China (52%) and Brazil (47%) show the highest adoption levels.	Precision farming increases crop productivity while reducing input costs and resource wastage.
AI Applications	Drones, robotics, smart irrigation, and digital advisory systems are increasingly adopted.	AI technologies improve crop monitoring, pest management, irrigation efficiency, and overall food availability.

Source: Compiled by the author using data from Oxford Insights (2024), FAO (2024), World Bank (2024), ITU (2024), and national agriculture reports (2024).

The above table compares the level of AI readiness and the adoption of smart agricultural technologies among the selected developing countries. China records the highest AI Readiness Index and precision farming adoption, followed by Brazil, indicating stronger technological preparedness and greater integration of AI into agricultural activities. India, Vietnam, and Indonesia demonstrate moderate progress, while Kenya lags behind due to lower digital readiness. The increasing use of AI applications, including drones, robotics, smart irrigation, and digital advisory services, enables farmers to improve crop management, optimize resource utilization, and reduce production risks. These technological advancements contribute to higher agricultural productivity and strengthen food security by ensuring efficient and sustainable food production.

These findings suggest that higher AI readiness accelerates the adoption of smart agricultural technologies, thereby improving agricultural productivity, resource efficiency, and long-term food security.

Table 5.
Analysis of Sustainable Agriculture and Food Security

Indicator	Key Finding	Link to Food Security
Irrigation Efficiency	China (69%) records the highest efficiency.	Efficient water management enhances crop production under changing climatic conditions.
Fertilizer Use Efficiency	China (78%) and Brazil (74%) perform better than other countries.	Efficient fertilizer use improves soil productivity and reduces environmental degradation.

Food Security Index	China (79) and Brazil (76) achieve higher food security scores.	Sustainable agricultural practices contribute to stable food production and improved food security.

Source: Compiled by the author using data from FAOSTAT (2024), World Bank (2024), and Global Food Security Index (2024).

The results indicate that countries with higher irrigation and fertilizer use efficiency also achieve better food security outcomes. China and Brazil perform strongly across all three indicators, suggesting that efficient resource management and the adoption of smart agricultural technologies contribute to sustainable agricultural development. These findings highlight the importance of improving water-use efficiency, optimizing fertilizer application, and promoting AI-supported farming practices to strengthen food security in developing countries.

The results demonstrate that AI-supported sustainable agricultural practices, including efficient irrigation and fertilizer management, play an important role in strengthening food security and promoting sustainable agricultural development.

Table 6.
Analysis of Descriptive Statistics

Variable	Mean	Interpretation
Agriculture (% of GDP)	12.60	Agriculture continues to play an important role in developing economies.
Internet Users (%)	68.17	Moderate digital connectivity supports the gradual adoption of AI in agriculture.
AI Readiness Index	63.33	AI preparedness differs considerably across countries.
Precision Farming Adoption (%)	31.67	Smart agriculture adoption is increasing but remains uneven.
Food Security Index	70.50	Food security is moderate, with opportunities for improvement through digital agriculture.

Source: Author's calculations using data from World Bank (2024), FAOSTAT (2024), ILOSTAT (2024), ITU (2024), Oxford Insights (2024), and Global Food Security Index (2024).

The descriptive statistics indicate that agriculture continues to play a significant role in the selected developing countries despite differences in economic structure. Moderate levels of internet connectivity and AI readiness suggest that digital transformation in agriculture is underway, although adoption remains uneven. The average precision farming adoption rate of 31.67% reflects the early stage of AI integration in agriculture, while the mean Food Security Index of 70.50 indicates scope for strengthening food security through wider adoption of smart agricultural technologies and improved digital infrastructure.

The descriptive statistics further indicate that countries with higher levels of AI readiness and digital connectivity tend to achieve better food security outcomes, emphasizing the importance of AI-driven agricultural transformation.

Table 7.
Analysis of Correlation Results

Relationship	Correlation (r)	Interpretation	Food Security Implication
AI Readiness – Precision Farming	0.99	Very strong positive	Higher AI readiness leads to greater adoption of smart farming technologies.
Internet Users – AI Readiness	0.97	Very strong positive	Better digital infrastructure strengthens AI adoption.
Internet Users – Precision Farming	0.96	Very strong positive	Internet access accelerates technology adoption in agriculture.
AI Readiness – Food Security	0.96	Very strong positive	AI adoption contributes significantly to improved food security.
Precision Farming – Food Security	0.95	Very strong positive	Precision farming enhances productivity and strengthens food security.

Source: Author's calculations using data from World Bank (2024), FAOSTAT (2024), ILOSTAT (2024), ITU (2024), Oxford Insights (2024), and Global Food Security Index (2024).

The correlation analysis reveals strong positive relationships among AI readiness, internet connectivity, precision farming, and food security. The highest correlation ($r = 0.99$) between AI readiness and precision farming indicates that countries with better technological preparedness are more likely to adopt AI-driven agricultural practices. Similarly, strong positive relationships between internet usage and AI readiness ($r = 0.97$), internet usage and precision farming ($r = 0.96$), and AI readiness and food security ($r = 0.96$) demonstrate the importance of digital infrastructure in agricultural transformation. The positive association between precision farming and food security ($r = 0.95$) suggests that wider adoption of AI-enabled farming technologies can enhance productivity, optimize resource utilization, and strengthen food security in developing countries.

These relationships confirm that AI-driven smart agriculture plays a significant role in improving food security through enhanced technological readiness, digital infrastructure, and precision farming adoption.

III. Results and Discussion

The findings reveal considerable differences in agricultural development, AI adoption, and food security among the selected developing countries. Kenya and India are more dependent on agriculture for GDP and employment, while China and Brazil have stronger digital infrastructure, creating favourable conditions for AI adoption.

China records the highest AI Readiness Index (83) and precision farming adoption (52%), followed by Brazil. These countries also achieve better irrigation efficiency, fertilizer use efficiency, and Food Security Index scores, indicating that greater AI adoption supports sustainable agricultural practices and improved food security.

The descriptive statistics show moderate levels of AI readiness (63.33), precision farming adoption (31.67%), and food security (70.50), suggesting that the adoption of smart agriculture is progressing but remains uneven across the selected countries.

Correlation analysis reveals a very strong positive relationship between AI readiness and precision farming adoption ($r = 0.99$), AI readiness and food security ($r = 0.96$), and precision farming adoption and food security ($r = 0.95$). These findings indicate that improved digital infrastructure and AI-enabled farming technologies enhance agricultural productivity, optimize resource use, and contribute to better food security. Overall, AI-driven smart agriculture offers significant opportunities for achieving sustainable agricultural development in developing countries.

Overall, the comparative analysis confirms that AI-driven smart agriculture serves as a key pathway for improving agricultural productivity, resource-use efficiency, and food security in developing countries. Countries with stronger digital infrastructure and higher AI readiness consistently demonstrate better adoption of precision farming technologies and improved food security performance, highlighting the importance of digital transformation for sustainable agricultural development.

Major Findings of the Study

1. Agriculture continues to play a vital role in the selected developing countries, contributing an average of 12.60% to GDP and employing 30.50% of the workforce.
2. Digital readiness varies across countries. China and Brazil demonstrate higher AI readiness and precision farming adoption, while Kenya records the lowest levels.
3. Countries with better digital infrastructure and AI readiness achieve higher irrigation efficiency, fertilizer use efficiency, and Food Security Index scores.
4. The average AI Readiness Index (63.33) and precision farming adoption (31.67%) indicate that the adoption of smart agriculture is progressing but remains uneven among the selected countries.
5. Correlation analysis reveals a very strong positive relationship between AI readiness and precision farming adoption indicating that technologically prepared countries adopt smart farming practices more ext($r = 0.99$), ensively.
6. AI readiness ($r = 0.96$) and precision farming adoption ($r = 0.95$) are strongly associated with the Food Security Index, suggesting that AI-driven agriculture contributes to improved food security.

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7. Overall, the findings highlight that investment in digital infrastructure, AI technologies, and precision farming can promote sustainable agricultural development and strengthen food security in developing countries.

Policy Implications

1. Strengthen digital infrastructure and internet connectivity in rural and agricultural areas to facilitate the adoption of AI-enabled farming technologies.
2. Promote precision farming through financial incentives, subsidies, and affordable access to smart agricultural technologies, including drones, sensors, and digital advisory systems.
3. Enhance farmers' digital literacy and technical capacity through regular training programmes and AI-based agricultural extension services.
4. Increase public and private investment in AI research, innovation, and climate-smart agricultural practices to improve productivity and resource-use efficiency.
5. Foster collaboration among governments, research institutions, universities, and agritech companies to accelerate the development and diffusion of AI-driven agricultural solutions.
6. Develop inclusive policies that ensure small and marginal farmers have equitable access to AI technologies, thereby promoting sustainable agricultural development and improving food security.

The findings of this study provide practical insights for policymakers, agricultural extension agencies, researchers, agritech firms, and development organizations in designing and implementing AI-enabled agricultural strategies. The study highlights the importance of strengthening digital infrastructure, enhancing AI readiness, and promoting precision farming to improve agricultural productivity, optimize resource utilization, and strengthen food security in developing countries. The findings may also support evidence-based policy formulation and investment decisions aimed at achieving sustainable agricultural development.

IV. Limitations of the Study

The present study is subject to certain limitations. First, it relies exclusively on secondary data collected from internationally recognized sources for the year 2024, which provides a cross-sectional perspective rather than capturing changes over time. Second, the analysis is limited to six developing countries; therefore, the findings may not be generalizable to all developing economies. Third, the study employs descriptive statistics and correlation analysis, which identify patterns and associations but do not establish causal relationships. Future research may extend the analysis by using panel data over multiple years, incorporating a larger sample of countries, and applying advanced econometric techniques such as panel regression, fixed-effects, or random-effects models to provide deeper insights into the impact of AI-driven smart agriculture on food security.

V. Conclusion

The study demonstrates that AI-driven smart agriculture has significant potential to improve food security and promote sustainable agricultural development in developing countries. The comparative analysis shows that countries with higher AI readiness, stronger digital infrastructure, and greater adoption of precision farming achieve better agricultural efficiency and food security outcomes. The findings also reveal a strong positive relationship between AI readiness, precision farming, and food security, highlighting the importance of digital transformation in agriculture. Strengthening digital infrastructure, expanding access to AI technologies, and enhancing farmers' technical skills will be essential for achieving resilient and sustainable food systems in developing countries. The findings of this study support the achievement of SDG 2 (Zero Hunger), SDG 9 (Industry, Innovation and Infrastructure), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) by demonstrating the potential of AI-driven smart agriculture to enhance food security and promote sustainable agricultural development.

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