

# Artificial Intelligence in Agriculture: Application in Developing Countries

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Received: May 14, 2024      Accepted: July 27, 2024      Online Published: November 15, 2024

doi:10.5539/jas.v16n12p60      URL: <https://doi.org/10.5539/jas.v16n12p60>

## Abstract

The economic sector is significantly impacted by agriculture. Artificial intelligence is being applied in agriculture to automate numerous tasks, reduce hazards, and provide farmers with a comparatively easy-to-use farming system but a revolution is taking place in the field of agriculture, utilizing artificial intelligence (AI) to solve major issues confronting the agricultural sector in developing nations. A focus on the impact and potential benefits of AI in developing nations is explored in this paper.

The widespread adoption of AI in agriculture in developing countries has been confronted by challenges such as infrastructure deficits, high investment costs, and a lack of capacity building. Governments, policymakers, researchers, and technology providers must work together to ensure sustainable and inclusive deployment of AI technologies in agriculture.

A critical examination of the state of agriculture in developing countries is the primary objective of this study, as well as the identification and mitigation of farmer challenges with the use of AI technologies. But a revolution is taking place in agriculture, utilizing artificial intelligence (AI) to solve major issues confronting the agricultural sector in developing nations.

**Keywords:** artificial intelligence, agriculture, developing countries

## 1. Introduction

Agricultural practices include cultivating the land, raising crops, and rearing livestock for human consumption. The process also involves the production of raw materials for the manufacturing industry as opined by Vangala et al. (2022), aside from its contribution to the economy, agriculture provides raw materials for several vital sectors. According to Zakaria and Hassan (2022), as a fundamental pillar of economic and social development, agriculture supplies humans and animals with food, feed, fiber, and fuel that meet their nutritional needs. As emphasized by Chawla et al. (2023), agricultural activities are, therefore, imperative to the sustainability of human activity as a whole. Around the globe, challenges include the growth of the population and competition for resources.

United Nations (2021), however, stated that as of 2030, there are many differences between where the world is today and six years ago when food insecurity, hunger, and all forms of malnutrition were ended. COVID-19 exacerbated the hunger crisis in 2020, with an increase in hungry people worldwide. In 2020, the global undernutrition rate grew even more as in 2020, 720 to 811 million people worldwide experienced hunger. It is expected that the global artificial intelligence in the agriculture market will generate a revenue of \$8,379.5 million by 2020-2030, an increase of 24.8% over the forecast period (Atlas, 2020). Artificial intelligence, then, refers to the process of creating intelligent machines employing science and engineering, especially using intelligent computer programs.

A wide range of technological advancements can be used to resolve industry challenges, including machine learning, artificial intelligence, blockchain technology, and information and communication. As revealed by Zakaria and Hassan (2023), one of the most critical emerging disruptive digital technologies includes artificial intelligence (AI). With artificial intelligence, producers, retailers, and most importantly smallholder farmers gain better insights into the whole value chain of agricultural inputs, resulting in a more transparent relationship between all parties.

As stated by Revanth (2019), technological advancements have significantly affected the agricultural industry over the years. United Nations (2015), however, stated that many countries worldwide rely on agriculture as their main source of income, and as United Nations projections show, by 2050 the population will reach 9.7 billion, and agriculture will become even more important. Further, Revanth (2019) and Dmytro (2022), explained that by 2050, only 4% of the world's land will be under cultivation, causing more pressure on land. Hence, it will be difficult to feed another two billion individuals without increasing food output by 50%. Therefore, farmers will have to work harder with fewer resources. By integrating artificial intelligence solutions, farmers can improve efficiencies, increase yields, enhance quality, and streamline the process of bringing their crops to market faster.

## **2. The Function of Artificial Intelligence in Agriculture**

Using artificial intelligence, farmers can reduce errors and minimize crop failure risks by forecasting and predicting future events. As emphasized by Eray (2022), it was estimated that 44 nations as of October 2021 had established their own AI strategic plans. This proved their desire to lead the world in Artificial intelligence. According to Michael et al. (2021), a farmer can take advantage of global climate change to provide accurate and timely weather information that is favorable for planting during times of global climate change. Eray (2022), however, indicated that China and India are among the emerging economies developing AI programs at a rapid pace.

Michael et al. (2021) explain that farmers use soil and crop health monitoring systems to make informed decisions about fertilizers, pesticides, and other inputs. Kim et al. (2008), however, emphasized that artificial intelligence can identify the type of soil and crop to plant according to soil and crop conditions. According to Louis (2021), the combination of artificial intelligence, machine learning, and Internet of Things (IoT) sensors that produce real-time data through the application of predetermined algorithms has boosted agricultural productivity, improved the productivity of crops, and reduced the expenses associated with the production of food. Louis (2021) pointed out that methods such as applying machine learning-based surveillance systems to monitor field crops have given efficient mechanisms for preserving remote facilities, boosting crops, and discouraging trespassers while also identifying the employees working there (Michael et al., 2021). Subsequently, crop prediction yields can be guaranteed with the integration of real-time sensor data and the utilization of visual analytics data from drones. Furthermore, Michael et al. (2021) indicated that in the agricultural sector, artificial intelligence has resulted in efficient water management, crop rotation, timely harvesting, and crops planted in the right way as well as managing pests and diseases.

A wide range of problems can be addressed and production processes optimized with artificial intelligence techniques in agriculture, food, and biotechnology. It would have been impossible even a decade ago to imagine the impact of digital technologies on agriculture. Artificial intelligence, robotics, satellite technology, and advanced technology with remote sensing mapping help enhance outputs and productivity. New technology is usually expensive to purchase and requires high levels of expertise for it to be operated. Therefore these tools have historically been reserved for large farms in developed nations.

Aside from access to modern technology, farmers in emerging economies or developing countries still face many of the same problems they had decades ago, including inadequate or inappropriate inputs, a shortage or lack of technical support and training, a lack of market connectivity, significant losses throughout the entire supply chain, and a lack of accessible financing. The dilemma is made worse by the impact of climate change consequences because small farm holdings are less resilient, endangering revenue for households as well as larger issues related to food security.

## **3. Benefits of Artificial Intelligence in Agriculture**

Agriculture is no exception to the transformative power of Artificial Intelligence (AI). Due to its potential to address farmers' unique challenges, particularly in developing countries, AI has received increasing attention in agriculture over the past few years. According to Javaid et al. (2022), many developing economies rely heavily on agricultural production, so integrating AI technologies offers opportunities to improve productivity, sustainability, and resilience.

The population is growing rapidly, leading to a rise in the need for food and employment. So many farmers in developing countries are unable to meet the requirements of their crops using traditional methods. As a result of new automated methods, billions of people in developing countries will be able to gain employment opportunities while also meeting their food needs. The advent of artificial intelligence has sparked a new era in agriculture, according to Tanha et al. (2020). This technique has protected agricultural output from a number of factors, including population growth, employment issues, and food security concerns (Tanha et al., 2020). In agreement with Kim et al. (2008), and Tanha et al. (2020), artificial intelligence-based technology is beneficial

to a range of industries, especially agriculture, in increasing productivity and resolving crop yield, irrigation, soil content sensing, crop monitoring, weeding, and crop establishment difficulties. Panpatte (2018) indicates that artificial intelligence makes it possible for farmers to collect and analyze vast amounts of data from government websites and provide answers to many ambiguous questions. A farmer can use artificial intelligence to process large amounts of data to make better crop management, soil health, and water management decisions. A computer program can also assist farmers in identifying potential risks, such as pests and diseases, and suggest strategies to mitigate them. Using artificial intelligence, you can also identify the right time to plant crops, optimize fertilizer and pesticide use, and provide early weather warnings

Aside from predicting yields and analyzing the impacts of climate change, AI can also help farmers anticipate global warming. Thus, AI can identify weather patterns and trends in plant growth rapidly and accurately by analyzing a large amount of data. As a result, decisions can be made about planting crops and fertilizer and pesticide application and when to plant them. Droughts, floods, and extreme temperatures can also be predicted with AI, which can be devastating to farmers in the event of extreme weather events.

#### 4. Impact of AI on Agriculture in Developing Countries

United Nations (2021) indicated that in 2020, 46 million more Africans were affected by hunger than in 2019, making up 768 million undernourished people worldwide. Anna and Nicholas (2022), however, highlighted the fact that according to the World Bank's on report "Agricultural Technology and Productivity Growth", as of 2017, malnutrition afflicted an estimated 821 million people. Taking into account these seemingly immutable obstacles, Anna and Nicholas (2022) went on to clarify that there can be hope for helping farmers in developing countries realise their immense potential in agriculture and maximise their yields owing to the inventiveness and collaboration of several institutions, non-governmental organizations, and researchers. Because of a multitude of apps, databases, forecasting techniques, and other technology platforms, some small-scale farmers these days are using more tools than those found only in the developed nations. Some of those tools are shown in Table 1.

Table 1. Assessable tools

S/N	Accessible Tools	Utilization
1	PLANTIX	PEAT GmbH, the German-Indian start-up, has developed an application called Plantix that could have a significant impact on how small-scale farmers access field data. This app integrates a lot of knowledge from top academic institutions around the world with artificial intelligence. It is accessible in 150 countries and 18 languages. An image of a farmer's crop can be used to determine what is harming the crop if it is taken with Plantix, which has a library of over fifty million crop images. According to Anna and Nicholas (2022), PEAT GmbH quoted, "we developed the app to serve as a knowledge-transfer tool for small-scale farmers in developing countries.
2	RICULT	Ricult Pakistan helps farmers manage crops, increase outputs, and increase profitability by giving them instant access to information about their agricultural activities. To increase supply chain efficiency and lower the risk associated with it, the app provides a broad range of great models. Thus Ricult's app, according to Simonet and Ali (2022), provides access to weather data and farm health via satellite imagery and scans a wide geographical area to determine crops and growth stages that can all be used by this app to calculate the average irrigation cycle over a monthly period.
3	4CAST	With 4CAST, which stands for Digital Tools for Cataloguing and Adopting Improved Seed Technologies, 4CAST will also deliver a digital workflow for seed value chains, decentralized access, real-time tracking, personal catalogs, and seed roadmaps for stakeholders (AgNews, 2021). However, 4CAST, enhances farmers' access improved seed varieties best suited to their region or climate based on specific information.

AI impacts agricultural production, management, and sustainability in developing countries in multiple ways. Even though AI has yet to be fully utilized in agriculture, several notable effects have already been observed:

##### (1) Increased Productivity and Efficiency

ML predictive analytics, and robotics are AI technologies that help farmers improve their agricultural production, increasing productivity and efficiency. In addition to providing actionable insights into weather patterns, soil conditions, and crop health, a computer system can plan when and how to plant, irrigate, fertilize, and manage pests to increase yields and reduce resource consumption.

##### (2) Precision Agriculture Practices

Agricultural inputs, such as water, fertilizer, and pesticides, can be tailored according to specific crop needs and field conditions through artificial intelligence. Particularly in resource-scarce or expensive regions, this targeted approach minimizes input costs, reduces environmental impact, and maximizes resource efficiency.

### (3) Improved Pest and Disease Management

Using AI-powered monitoring systems, pest infestations and diseases can be detected early, enabling timely intervention and mitigation. Artificial intelligence algorithms can identify pest outbreaks and disease hotspots through data analysis by sensors, drones, and satellite imagery, which will aid farmers in implementing preventive measures to minimize crop loss.

### (4) Labor Savings and Automation

Planting, weeding, and harvesting are among the labor-intensive tasks that can be automated using AI-driven robotics and automation technologies. Agriculture as a livelihood option becomes more appealing in developing countries with labor shortages or high labor costs when AI-enabled machinery improves efficiency, reduces drudgery, and reduces drudgery.

### (5) Enhanced Access to Agricultural Information

Farmers are empowered to make informed decisions by AI-based advisory systems, which provide personalized recommendations and agronomic advice. By providing smallholder farmers with access to market prices, weather forecasts, best practices, and extension services, mobile applications and digital platforms equipped with artificial intelligence algorithms bridge information gaps and facilitate technology adoption.

### (6) Resilience to Climate Change

Adapting to climate change can be achieved with artificial intelligence by providing early warning systems for extreme weather events, maximizing resource utilization in water-stressed environments, and developing crop varieties that are more resilient to climate change. Climate-smart agricultural practices can be implemented by using AI models to analyze past weather data and predictions of future climates.

### (7) Empowerment of Smallholder Farmers

Agricultural knowledge, markets, and services can be democratized through AI to empower smallholder farmers. Farm businesses can improve their competitiveness and livelihoods by leveraging AI solutions, which are affordable and scalable.

### (8) Sustainable Agriculture Practices

Using AI to optimize resource use, minimize environmental impacts, and promote ecosystem health is one way that AI promotes sustainable agriculture practices. The application of artificial intelligence in agricultural systems contributes to sustainable intensification and resilience-building through precision farming, soil conservation, and biodiversity preservation.

AI has a transformative impact on agriculture in developing countries, offering opportunities to promote productivity, increase efficiency, and address pressing challenges. Access to technology, capability building, and policies are barriers to realizing AI's full potential, along with ensuring that AI applications are inclusive, ethical, and adapted to local conditions. Agricultural development and food security in developing countries can be advanced through strategic investments, partnerships, and innovation. Through the application of AI techniques, farmers can estimate when to plant and harvest their crops and monitor their crops more effectively. It additionally has the potential to evaluate a single plant at a time and add insecticides solely for sick trees and plants, as opposed to spraying insecticides across large areas of crops.

Future growth in the global AI market for agriculture is expected to be substantial. In real-time, farmers are able to monitor livestock using artificial intelligence. Many artificial intelligence solutions are now available that allow dairy farms to monitor the behavior aspects of each animal on their farms. These solutions include body condition scores, feeding patterns, and facial recognition. Farmers also use machine vision for recognising undetected trends and facial features.

## 5. What Makes Farmers' Implementation of Artificial Intelligence So Difficult?

Dmytro (2022), however, stated that it is difficult for farmers to talk about yields when the weather is bad or crops are infected with diseases. A pandemic, for example, can suddenly make the management of various processes difficult since most are nondigital. According to Torky and Hassanein (2020), in the present day, precision farming relies on AI, IoT, mobile applications, blockchain, drones, cloud computing, and smart sensors. The access and

processing of instantaneous information about crops, the state of the soil, the climate, food safety, crop and fruit distribution systems, livestock grazing, and numerous other pertinent services has been made possible, according to Torky and Hassanein (2020). This was made practicable by earlier technologies.

Using AI-based systems with expertise will enhance agricultural operations (Slaughter et al., 2008). The data-driven approach will make agricultural decision-making more efficient and provide support for data-driven agriculture. The prohibitive price of AI technology as an investment is one of the biggest problems facing farmers (Shobila & Mood, 2014). Artificial Intelligence systems demand large expenditures for hardware, software, training, and support. Farmers on a smaller scale may find this to be a big obstacle because they frequently have few resources. A small-scale farmer, for instance, might not have the money to buy and maintain an AI system in a developing country. Comparatively, larger farms that can utilize these technologies are at a disadvantage.

AIs are often thought to pertain exclusively to the digital world by farmers. The area could be cleared for farming but they may not realize how it can facilitate the process. In other words, they are not being conservative or afraid of the unknown. Because they are unfamiliar with the practical application of artificial intelligence, they exhibit a reluctance to adopt it. The training and support required by farmers to use AI systems effectively may be lacking in rural parts of developing countries. Comparatively, farmers in countries with more developed economies eke out a smaller competitive advantage. According to Dmytro (2022), emerging technologies often appear complex and excessively expensive because AgriTech companies fail to articulate why their solutions are valuable. Thus, Agriculture is affected by artificial intelligence. Despite AI's potential benefits, technology companies need to do more to help farmers take advantage of it.

The majority of farmers are reluctant to implement the changes brought on by emerging technologies. Inadequate training, a lack of knowledge, and an inability to experience new systems are contributing factors to this. Even though AI has the potential to drastically enhance farmers' operations, this can make it challenging for them to completely embrace it. For instance, farmers in some areas may be reluctant to implement new technology because they view it as alien and strange because they have been using conventional farming practices for decades.

Considering these drawbacks, the implementation of artificial intelligence in agriculture is growing in popularity, and farmers that adopt these cutting-edge innovations are bound to see enhanced productivity, reduced expenses, and increased profits.

In developing countries, governments, charitable organizations, and the commercial sector have to collaborate to give farmers the resources and encouragement needed to implement artificial Intelligence for farming to get around these obstacles. This entails granting access to reasonably priced technology, instruction, and encouragement as well as fostering a legislative environment that promotes innovation and financial investment in this area.

## 6. Conclusion

As agricultural practices are revolutionized, productivity improves, and food security is enhanced, particularly in developing countries, by the application of artificial intelligence (AI). Several key points emerge from this paper as outlined below:

### (1) Increased Productivity and Efficiency

Farmers can make data-driven decisions, optimize resource use, and increase crop yields with AI technologies such as predictive analytics, precision agriculture, and automated farming systems. Developing countries must achieve these efficiency gains as they face challenges like climate change and limited arable land.

### (2) Resource Sustainability and Optimization

With AI-based solutions, farmers can monitor soil health, weather patterns, and crop conditions in real time, allowing them to optimize the use of water, fertilizer, and pesticides. Sustainable agricultural practices and mitigating water scarcity and soil degradation can be achieved through these technologies by minimizing waste and environmental impact.

### (3) Access to Expertise and Information

Agricultural information, market insights, and expert advice are readily available to farmers in remote or underserved areas thanks to AI-powered platforms and mobile applications. Increasing income and improving farm techniques are two benefits of this democratization of knowledge for smallholder farmers.

### (4) Resilience to Climate Change

Droughts, floods, and pest outbreaks are some of the climate-related risks that farmers can anticipate and adapt to with AI-based climate modeling and early warning systems. Climate change impacts can be mitigated, crops can be diversified, and farmers can build resilience with these technologies, which provide timely alerts and recommendations.

#### (5) Poverty Alleviation and Economic Development

As AI technology is adopted in agriculture, rural communities can benefit economically and alleviate poverty. Farmers are lifted out of poverty by these innovations because they improve agricultural productivity and market access.

#### (6) Challenges and Considerations

Despite AI's potential benefit for agriculture, it faces several obstacles in developing countries, including limited technology access, insufficient infrastructure, and socioeconomic barriers. The investments in digital infrastructure, the support of technology transfer, and capacity building initiatives that are needed to address these challenges require a concerted effort from governments, private sector stakeholders, and international organizations.

Using artificial intelligence to transform agricultural production, distribution, and consumption in developing countries holds immense promise. AI technology can boost agriculture's resilience, sustainability, and inclusion to ensure food security and prosperity for future generations.

### **7. Recommendation**

Agricultural technology is becoming more advanced with the help of technologies such as artificial intelligence. Applications of artificial intelligence are being implemented to enhance social, economic, and ecological efficiency in developing countries. To address key challenges faced by the agricultural sector in developing countries, the following recommendation can be utilized to integrate AI.

#### *7.1 Investment in Infrastructure*

Digital infrastructure investments, including improved internet connectivity and storage facilities, should be prioritized by governments and stakeholders in developing countries. This will enable the seamless implementation and scaling of agricultural AI.

#### *7.2 Capacity Building*

To enhance farmers' digital literacy, create training programs and workshops. AI-driven systems can only be adopted successfully if people are well-appointed with the necessary skills to operate and maintain them.

#### *7.3 Data Accessibility and Management*

Ensure that agricultural data can be shared online through open data platforms. The use of diverse datasets will improve the accuracy of AI algorithms and provide farmers with valuable insights.

#### *7.4 Tailored Solutions*

Develop artificial intelligence applications geared specifically toward the needs and conditions of farmers in developing countries. In order for AI technologies to be inclusive and effective, smallholder farmers, diverse crop types, and regional variations need to be taken into consideration.

#### *7.5 Public Private Partnership*

Collaboration between government, private sector, and academic institutions is key to driving innovation in agriculture using AI. Developing, testing, and deploying AI solutions can be accelerated through public-private partnerships.

#### *7.6 Policy Framework*

Support the development and implementation of supportive regulatory frameworks to address ethical issues, data privacy, and responsible AI usage in agriculture. In addition to protecting farmers' interests, clear policies will make AI adoption more conducive.

#### *7.7 Farmers' Involvement and Feedback*

Ensure that farmers are involved in the decision-making process when it comes to AI adoption. Make sure that AI applications align with farmers' needs, preferences, and cultural contexts during the development and implementation phases.

#### *7.8 Financial Support*

Financing, subsidies, or grants are provided to farmers to encourage them to adopt AI technologies. AI solutions can be made more widely available with financial support to offset the initial costs.

#### 7.9 Monitoring and Evaluation

Ensure that AI applications in agriculture are incessantly monitored and evaluated. Assessing AI on a regular basis will allow for the identification of challenges, the measurement of its impact on production, and the refinement of sustainable improvement strategies.

#### 7.10 International Collaboration

Cooperate with international organizations, researchers, and developing countries to exchange knowledge. AI adoption in agriculture will be accelerated by sharing experiences and best practices.

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**Acknowledgments**

Not applicable.

**Authors Contributions**

Not applicable.

**Funding**

Not applicable.

**Competing Interests**

Not applicable.

**Informed Consent**

Obtained.

**Ethics Approval**

The Publication Ethics Committee of the Canadian Center of Science and Education. The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

**Provenance and Peer Review**

Not commissioned; externally double-blind peer-reviewed.

**Data Availability Statement**

The data supporting this study's findings are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

**Data Sharing Statement**

No additional data are available.

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