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AI in Agriculture: A Comparative Review of Developments in the USA and Africa

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Abstract
This comparative review explores the advancements and applications of Artificial Intelligence (AI) in agriculture, focusing on the developments in the United States (USA) and Africa. The integration of AI technologies in agriculture has witnessed significant progress globally, addressing challenges and transforming traditional farming practices. In the USA, precision agriculture and smart farming techniques driven by AI have become integral components of modern agricultural systems. These innovations include autonomous machinery, drone technology for crop monitoring, and predictive analytics for yield optimization. In contrast, the application of AI in African agriculture presents a distinct set of challenges and opportunities. The review delves into initiatives aimed at leveraging AI to enhance agricultural productivity, improve resource management, and address food security concerns in various African nations. These efforts include the deployment of AI for pest and disease detection, crop monitoring in remote areas, and the implementation of data-driven decision-making tools to support smallholder farmers. The comparative analysis sheds light on the disparities in AI adoption between the USA and Africa, emphasizing factors such as infrastructure, technological accessibility, and resource availability. Additionally, it explores collaborative efforts and partnerships that bridge the gap and contribute to the sustainable development of AI in African agriculture. As both regions navigate the complexities of implementing AI in agriculture, this review underscores the potential for technology to play a pivotal role in addressing global food challenges. The findings highlight the need for tailored approaches, policy frameworks, and international collaborations to ensure inclusive and equitable access to AI-driven innovations in agriculture, fostering a shared commitment to sustainable and technologically empowered farming practices.

Keywords: AL, Agriculture, Developments, Comparative, Collaborative

1. Introduction

In recent years, the integration of Artificial Intelligence (AI) into various sectors has sparked transformative advancements, and agriculture is no exception. The application of AI in agriculture has emerged as a powerful tool, revolutionizing traditional farming practices and offering innovative solutions to global food challenges (Javaid *et al*., 2022; Sharma, *et al*., 2022) [30, 54]. This comparative review delves into the developments of AI in agriculture, focusing on a comparative analysis between the United States (USA) and the diverse agricultural landscape of Africa.

Artificial Intelligence in agriculture refers to the utilization of advanced technologies, including machine learning, data analytics, and automation, to enhance various aspects of agricultural processes (Smith, 2018; Misra, *et al*., 2020) [55, 40]. This encompasses a wide range of applications, from precision farming and crop monitoring to predictive analytics for yield optimization. AI in agriculture leverages data-driven insights and computational capabilities to make informed decisions, increase efficiency, and address complex challenges faced by the agricultural sector. The significance of AI in agriculture lies in its ability to bring about a paradigm shift in traditional farming methodologies (Bannerjee, *et al*., 2018) [14]. Through the integration of cutting-edge technologies, AI facilitates precise and efficient management of resources, optimizing crop yields, reducing environmental impact, and enhancing overall productivity. From autonomous machinery and smart sensors to advanced analytics, AI empowers farmers with tools to make informed decisions, mitigating risks and contributing to sustainable and resilient agricultural practices.

The purpose of this comparative review is to explore the varied landscape of AI adoption in agriculture by juxtaposing the developments in the USA and Africa. While the USA represents a technologically advanced agricultural sector with sophisticated infrastructure, Africa presents a unique context marked by diverse agricultural practices, varying levels of technological accessibility, and distinct challenges. Through this comparative analysis, we aim to highlight the disparities, challenges, and opportunities in AI adoption in both regions. Additionally, the review seeks to underscore the importance of collaborative efforts, policy frameworks, and inclusive approaches to ensure that the benefits of AI in agriculture are realized globally, fostering sustainable and equitable advancements in the field (Khandelwal, and Chavhan, 2019) [35].

2.1 Developments in AI in Agriculture: USA

Artificial Intelligence (AI) has significantly reshaped the landscape of agriculture in the United States, fostering a new era of efficiency, sustainability, and precision. The integration of AI technologies into agricultural practices has led to groundbreaking developments, revolutionizing the way crops are cultivated, monitored, and optimized. This exploration will delve into key advancements in AI in agriculture in the USA, with a focus on Precision Agriculture, Drone Technology for Crop Monitoring, and Predictive Analytics for Yield Optimization. Precision Agriculture represents a paradigm shift in farming practices, emphasizing data-driven decision-making and targeted resource management (Sood, *et al*., 2022; Adeleke *et al*., 2019) [56, 4]. This approach harnesses the power of AI to enhance the accuracy and efficiency of various agricultural processes.

One of the cornerstones of Precision Agriculture in the USA is the deployment of autonomous machinery. AI-driven tractors and harvesters equipped with advanced sensors and GPS technologies enable farmers to perform precise tasks with minimal manual intervention. These autonomous machines operate based on real-time data, optimizing the use of inputs such as seeds, fertilizers, and pesticides. This not only reduces operational costs but also minimizes environmental impact by ensuring that resources are applied precisely where and when needed. Precision Agriculture relies heavily on sensor technologies that gather data from the field to inform decision-making. AI-powered sensors are capable of monitoring soil health, moisture levels, and crop conditions. These sensors provide farmers with valuable insights into the overall health of their crops, allowing for timely interventions to address issues such as nutrient deficiencies or pest infestations. The integration of sensors into farm equipment creates a connected ecosystem where data is continuously collected, analyzed, and used to optimize agricultural practices (Hassan, *et al*., 2022; Qazi, *et al*., 2022) [27, 50].

Drone technology has emerged as a transformative tool in agriculture, offering a bird's-eye view of fields and enabling farmers to monitor crops at a level of detail previously unimaginable. AI-driven drones have become essential in crop surveillance and management. Drones equipped with high-resolution cameras and multispectral sensors capture detailed imagery of fields. AI algorithms analyze this data to identify areas of concern, such as signs of disease, nutrient deficiencies, or water stress (Dutta, and Goswami, 2020; Hafeez, *et al*., 2022) [19, 25]. This allows farmers to make targeted interventions, applying resources only where necessary. The real-time monitoring capabilities of AI-powered drones contribute to early detection of issues, preventing the escalation of crop problems and improving overall yield.

Predictive Analytics leverages historical data, weather patterns, and real-time information to forecast and optimize crop yields. By harnessing the power of AI algorithms, farmers can make informed decisions about planting, harvesting, and resource allocation (Shaikh, *et al*., 2022; Patel *et al*., 2023; Ilugbusi *et al*., 2020) [53, 49, 28]. AI analyzes vast datasets to identify patterns and correlations between various factors affecting crop yield. This includes climate conditions, soil quality, previous crop performance, and market trends. Predictive analytics models can then generate forecasts, helping farmers optimize planting schedules, adjust irrigation plans, and make strategic decisions to maximize overall yield. This not only improves productivity but also contributes to sustainable farming practices by minimizing resource waste and environmental impact.

The integration of AI into predictive analytics also enables farmers to assess the financial implications of different scenarios. For example, they can evaluate the potential impact of changing weather patterns on crop yields and adjust their strategies accordingly. This data-driven decision-making process enhances resilience in the face of uncertainties, providing a valuable tool for navigating the dynamic nature of agriculture. In conclusion, the developments in AI in agriculture in the USA, particularly in Precision Agriculture, Drone Technology for Crop Monitoring, and Predictive Analytics for Yield Optimization, showcase the transformative potential of technology in revolutionizing traditional farming practices. These advancements not only improve operational efficiency but also contribute to sustainable and environmentally conscious agriculture. As AI continues to evolve, its integration into agriculture holds the promise of further innovations, ensuring a more resilient, productive, and sustainable future for the agricultural sector in the United States.

2.2 Developments in AI in Agriculture: Africa

The agricultural landscape in Africa is diverse and plays a crucial role in the continent's economy, providing livelihoods for a significant portion of the population. However, African agriculture faces unique challenges, including limited access to resources, unpredictable weather patterns, and the prevalence of smallholder farming (Sampene, *et al*., 2022; Gwagwa, *et al*., 2021) [52, 23]. In recent years, there has been a growing recognition of the potential of Artificial Intelligence (AI) to address these challenges and enhance agricultural productivity across the continent. Pest and disease outbreaks pose significant threats to crop yields in African agriculture. Recognizing the importance of early detection and rapid response, AI-driven technologies are being employed to identify and manage these challenges.

AI-based image recognition and machine learning algorithms enable farmers to detect signs of pest infestations or diseases in crops. Smartphones equipped with AI applications can capture images of affected plants, and the algorithms analyze these images to identify specific pests or diseases. This timely information empowers farmers to take targeted measures, such as precision application of

pesticides or adopting resistant crop varieties, minimizing the impact on yields. In addition, initiatives leveraging AI-enabled remote sensing technologies contribute to large-scale monitoring of crops. Drones equipped with advanced sensors fly over agricultural fields, capturing high-resolution images that AI algorithms analyze for signs of pest damage or disease spread. This remote monitoring capability allows for swift responses over vast areas, particularly in regions where access to farmlands is challenging (Aguera, *et al*., 2020; Ilugbusi *et al*., 2020) [7, 28].

A significant portion of agricultural activities in Africa occurs in remote and rural areas, where traditional monitoring and data collection methods may be limited (Gikunda, 2024; Vincent *et al*., 2021) [22, 61]. AI technologies are playing a pivotal role in overcoming these challenges by providing innovative solutions for crop monitoring. Satellite imagery, coupled with AI algorithms, offers a scalable and cost-effective approach to monitor crop conditions across vast and remote landscapes. These technologies can assess factors such as soil health, vegetation indices, and crop growth patterns. The insights derived from AI-driven analysis aid farmers in making informed decisions about irrigation, fertilization, and pest control, contributing to improved overall crop management. Moreover, mobile applications equipped with AI capabilities are becoming instrumental in providing real-time information to farmers. These applications can deliver weather forecasts, crop advice, and market information, empowering farmers in remote areas with valuable insights for better decision-making. The combination of AI and mobile technologies is bridging the information gap and enhancing the resilience of agriculture in remote African regions (Jellason, *et al*. 2021) [31].

Smallholder farmers form the backbone of agriculture in Africa, and AI technologies are increasingly being tailored to address their specific needs. Data-driven decision-making tools are designed to provide actionable insights, empower farmers with relevant information, and enhance the efficiency of their farming practices.AI-driven advisory services leverage weather data, soil information, and historical crop performance to offer personalized recommendations to smallholder farmers. Mobile applications or voice-based interfaces allow farmers to access these services, receiving guidance on optimal planting times, irrigation schedules, and pest management strategies (Rutenberg, *et al*., 2021; Abrahams *et al*., 2023) [51, 1]. The democratization of such AI-powered tools ensures that even farmers with limited resources and education can benefit from advanced agricultural insights. Blockchain technology, often integrated with AI, is also being explored to improve transparency and traceability in agricultural supply chains. This ensures fair pricing for smallholder farmers and promotes sustainable and ethical practices. By enabling secure and transparent transactions, AI-powered blockchain solutions contribute to building trust in agricultural value chains.

In conclusion, the developments in AI in agriculture in Africa showcase innovative solutions that address the unique challenges faced by the continent's diverse agricultural landscape. From pest and disease detection to crop monitoring in remote areas and data-driven decision-making tools for smallholder farmers, AI is proving to be a transformative force in enhancing productivity and sustainability. As initiatives continue to evolve, there is potential for further collaboration, knowledge-sharing, and the creation of tailored solutions that empower African farmers, strengthen food security, and contribute to the overall advancement of agriculture across the continent (Foster, *et al*, 2023; Vincent *et al*., 2021) [21, 61].

2.3 Comparative Analysis

The integration of Artificial Intelligence (AI) in agriculture has become a global phenomenon, transforming traditional farming practices and contributing to increased productivity and sustainability (Lakshmi and Corbett, 2020) [36]. This comparative analysis delves into the developments of AI in agriculture in two distinct regions: the United States (USA) and Africa. Examining the disparities in AI adoption and exploring collaborative efforts, this analysis sheds light on the challenges, opportunities, and potential pathways for sustainable AI-driven agriculture on a global scale.

In the USA, the adoption of AI in agriculture benefits from robust infrastructure and widespread technological accessibility (Khan, *et al*., 2021; Lezoche, *et al*., 2020; Abrahams *et al*., 2023) [34, 37, 1]. The agricultural sector in the USA is characterized by advanced machinery, well-established communication networks, and access to high-speed internet (Tang, *et al*., 2021) [57]. These factors create an environment conducive to the deployment of AI technologies, enabling farmers to leverage precision agriculture, autonomous machinery, and data-intensive applications seamlessly. In contrast, Africa faces disparities in infrastructure and technological accessibility that impact the widespread adoption of AI in agriculture. Many regions lack reliable internet connectivity and face challenges in accessing advanced agricultural machinery. Limited infrastructure poses barriers to the deployment of AI-driven technologies, especially in remote and rural areas where a significant portion of agricultural activities occurs (Ly, 2021; Ozor, *et al*., 2023) [38, 48].

The USA benefits from abundant resources and a well-established agricultural research and development ecosystem. The availability of financial resources, skilled professionals, and research institutions fosters innovation and facilitates the implementation of AI technologies in agriculture. Large-scale farms in the USA often have the financial capacity to invest in cutting-edge technologies, contributing to the rapid adoption of AI-driven solutions. Conversely, resource constraints in many African nations present challenges to the widespread implementation of AI in agriculture. Limited access to funding, skilled personnel, and research infrastructure hinders the development and deployment of AI technologies. Smallholder farmers, who form a significant part of the agricultural landscape in Africa, may lack the resources to adopt expensive AI-driven tools and machinery (Amankwah-Amoah, & Lu, 2022; Gikunda, 2024) [10, 38, 22].

Recognizing the disparities in AI adoption, collaborative efforts are crucial to bridge the gap between developed and developing regions (Aderibigbe, *et al*., 2023; Adaga *et al*., 2024) [5, 3]. Initiatives focused on knowledge transfer, capacity building, and technology dissemination play a pivotal role in ensuring that the benefits of AI in agriculture are accessible to all. In the USA, efforts are underway to share expertise and technologies with developing regions. Collaborative projects involve training programs, workshops, and knowledge-sharing platforms that empower farmers and agricultural professionals with the skills needed

to harness AI for sustainable farming practices. In Africa, partnerships with international organizations, NGOs, and tech companies are instrumental in addressing the technological divide. These collaborations aim to provide access to AI tools, training programs, and infrastructure development. By leveraging expertise from developed regions, Africa can accelerate its adoption of AI in agriculture and overcome resource constraints.

The global nature of agricultural challenges requires international collaborations to develop sustainable AI solutions (Tzacho, *et al*., 2022; Abrahams *et al*., 2024) [59, 2]. Partnerships between countries, research institutions, and private entities facilitate the exchange of ideas, technologies, and best practices. In the USA, collaborative efforts extend beyond national borders to engage with global partners. Research institutions collaborate on projects that explore the application of AI in addressing shared challenges, such as climate change impacts on agriculture and the development of resilient crops. In Africa, international collaborations focus on empowering local communities with AI-driven tools tailored to their specific needs. Initiatives supported by global organizations aim to develop context-specific solutions, considering the unique challenges faced by African farmers. These collaborations prioritize sustainable agriculture practices, environmental conservation, and inclusive development.

In conclusion, the comparative analysis of AI in agriculture in the USA and Africa underscores the importance of understanding and addressing disparities in adoption. While the USA benefits from advanced infrastructure and resources, Africa faces challenges related to accessibility and implementation. Collaborative efforts and partnerships emerge as key strategies to bridge these gaps, ensuring that the benefits of AI in agriculture are accessible globally. By fostering knowledge exchange, capacity building, and international collaborations, the agricultural sector in both regions can embrace sustainable, technology-driven practices that contribute to global food security and environmental conservation (Oriekhoe, *et al*., 2024) [46].

2.4 Challenges and Opportunities

The integration of Artificial Intelligence (AI) in agriculture presents a transformative potential globally, yet the challenges and opportunities associated with its adoption vary significantly between developed and developing regions. This comparative review explores the unique landscape of challenges faced in implementing AI in African agriculture, juxtaposed with the opportunities for advancements and growth in both the USA and Africa (Araújo *et al*., 2021; Carlberg, and Jerhamre, 2021; Oliveira, and Silva, 2023; Hassan *et al*., 2024) [11, 16, 45, 26]. One of the primary challenges in African agriculture is the limited infrastructure and technological accessibility. Many regions lack reliable electricity, internet connectivity, and access to advanced machinery. This poses a significant barrier to the deployment of AI-driven technologies, hindering the adoption of precision agriculture, remote sensing, and other data-intensive applications. Without adequate infrastructure, the benefits of AI in optimizing resource management and improving yields may remain inaccessible to a large portion of farmers (Davis, and Deif, 2021; Thilakarathne *et al*., 2021) [17, 58].

Resource constraints and limited funding pose challenges to the widespread adoption of AI in African agriculture. Smallholder farmers, who constitute a significant portion of the agricultural landscape, often lack the financial resources to invest in AI-driven tools and technologies. Additionally, research institutions may face challenges in securing funding for the development and implementation of AI solutions tailored to the specific needs of African agriculture. The lack of financial resources can impede the development and deployment of AI applications that could enhance productivity and sustainability. The shortage of a skilled workforce proficient in AI technologies is a critical challenge in African agriculture. Training programs and educational initiatives focused on AI applications are essential to empower farmers and professionals with the knowledge needed to leverage these technologies effectively. However, the lack of comprehensive training programs and educational resources in many African nations hinders the broader adoption of AI in agriculture. Bridging the skills gap is crucial for ensuring that farmers can make informed decisions and optimize their agricultural practices using AI-driven tools (Williamson, *et al* 2021; Karunathilake, *et al*., 2023; Zhai, *et al*., 2020) [62, 33, 63].

In the USA, where infrastructure and technological accessibility are more advanced, precision agriculture has emerged as a significant opportunity. AI-driven technologies such as autonomous machinery, smart sensors, and data analytics enable farmers to implement sustainable and precision farming practices. The precise application of resources, including water, fertilizers, and pesticides, contributes to environmental conservation and reduces waste. The opportunity lies in further advancements and innovations within precision agriculture, ensuring that sustainable practices become the norm in modern farming (Balogun *et al*., 2024; Akindote *et al*., 2023) [13, 9]. In Africa, the opportunity for growth in precision agriculture lies in the development of context-specific solutions. Tailoring AI applications to the unique challenges and characteristics of African agriculture can enhance resource efficiency, improve yields, and contribute to sustainable practices. This includes the development of low-cost, scalable technologies that can be easily adopted by smallholder farmers in remote areas (Jerhamre, *et al*., 2022; Mohan, *et al*., 2023) [32, 41].

The use of AI-driven technologies in remote sensing and monitoring presents opportunities for both regions. In the USA, where large-scale farming is prevalent, AI-enabled drones and satellite imagery contribute to advanced crop monitoring. These technologies provide real-time insights into crop conditions, enabling farmers to detect issues such as diseases or nutrient deficiencies early on. The opportunity lies in further advancements in remote sensing technologies and the integration of AI algorithms for more accurate and detailed analysis. In Africa, the opportunity lies in leveraging remote sensing technologies to address specific challenges faced by smallholder farmers. AI-powered applications can provide actionable insights based on local conditions, enabling farmers to make informed decisions about irrigation, pest control, and crop management. The use of affordable technologies, such as mobile applications with AI capabilities, can extend these opportunities to even the most remote agricultural regions.

Data-driven decision-making is a crucial opportunity that can benefit farmers in both the USA and Africa. In the USA, where advanced analytics and big data are prevalent, farmers can harness AI to analyze vast datasets and make informed decisions about planting, harvesting, and resource

allocation. The opportunity lies in further advancements in AI applications that can handle large-scale data and provide actionable insights in real time. In Africa, the opportunity lies in democratizing access to data-driven decision-making tools for smallholder farmers. Mobile applications with AI capabilities can deliver personalized recommendations to farmers, considering local conditions and challenges. Collaborative efforts between tech companies, NGOs, and governments can play a significant role in providing these tools to farmers who may lack access to traditional agricultural extension services.

In conclusion, the challenges and opportunities of AI in agriculture present a nuanced landscape that varies between the USA and Africa. While challenges such as limited infrastructure and resource constraints persist in African agriculture, opportunities for advancements and growth exist in both regions. The key lies in developing context-specific solutions, fostering collaborations, and addressing the unique challenges of each agricultural landscape. By seizing these opportunities and overcoming challenges, AI in agriculture can contribute to increased productivity, sustainability, and food security on a global scale (Mishra, and Mishra, 2023; Babarinde *et al*., 2023; Ahmed, *et al*., 2022; Jabir, and Falih, 2020) [39, 12, 8, 29].

2.5 Future Outlook

The future of Artificial Intelligence (AI) in agriculture holds immense promise, offering transformative solutions to enhance productivity, sustainability, and global food security. This comparative review explores the future outlook of AI in agriculture, considering the potential impact on global food security, the need for tailored approaches and policy frameworks, and the imperative of ensuring inclusive and equitable access to AI-driven agricultural innovations (Bhangar, and Shahriyar, 2023) [15]. Examining developments in both the USA and Africa provides insights into the challenges and opportunities that lie ahead. The potential impact of AI on global food security revolves around its ability to enhance productivity and efficiency in agricultural practices.

In the USA, where advanced technologies are already integrated into large-scale farming operations, the future holds innovations that further optimize resource management, reduce waste, and increase overall yields. AI-driven precision agriculture, autonomous machinery, and data analytics are expected to play pivotal roles in achieving higher levels of productivity and ensuring a stable food supply. In Africa, the impact of AI on food security lies in the potential to uplift smallholder farmers and address specific challenges faced by the continent. Tailored AI solutions, such as mobile applications for crop monitoring and personalized recommendations, have the potential to improve yields, mitigate risks, and contribute to the overall food security of local communities (Dliang, and Chang, 2020; Okoro *et al*., 2024; Habyarimana, 2021) [18, 44, 24].

AI has the potential to enhance climate resilience in agriculture, addressing the challenges posed by climate change and variability. In the USA, AI applications that analyze weather patterns, soil health, and historical data can contribute to more informed decision-making. Farmers can adapt their practices in response to changing climate conditions, ensuring the continued production of essential crops. In Africa, where climate impacts are often more severe, AI-driven solutions can offer adaptive strategies for smallholder farmers. Predictive analytics, combined with local weather data, can assist farmers in making decisions that minimize the impact of climate-related challenges. By developing AI applications that specifically address the vulnerabilities of African agriculture to climate change, the continent can build resilience and ensure food security in the face of evolving environmental conditions (Qazi, *et al*., 2022; Adli *et al*., 2023; Orieno *et al*., 2024; Ohenhen *et al*., 2024) [50, 6, 47, 43].

The future of AI in agriculture requires the development of context-specific solutions that address the unique challenges and characteristics of each region. In the USA, the emphasis will be on refining and expanding existing AI applications in precision agriculture, data analytics, and remote sensing. Customized solutions that consider the diverse needs of various crops, climates, and farming practices will be crucial for maximizing the benefits of AI. In Africa, the need for tailored approaches is even more pronounced due to the diversity of agricultural landscapes and the prevalence of smallholder farming. Future AI applications should be designed with a deep understanding of local conditions, crop varieties, and resource constraints. Mobile-based solutions, considering the widespread use of smartphones in Africa, offer a practical avenue for delivering context-specific AI-driven insights to farmers.

As AI technologies continue to advance, the development of robust policy frameworks and ethical considerations becomes imperative. In the USA, where regulatory bodies are already engaged in overseeing aspects of AI in agriculture, the future will likely involve the refinement of existing policies and the introduction of new guidelines to address emerging challenges. Ensuring data privacy, ethical use of AI, and fair access to innovations will be key components of future policy frameworks. In Africa, the development of policy frameworks must consider the unique challenges faced by smallholder farmers and the potential for AI to exacerbate existing inequalities. Policymakers need to strike a balance between encouraging innovation and ensuring that the benefits of AI are shared equitably. This involves addressing issues such as data ownership, intellectual property rights, and the ethical deployment of AI technologies in agriculture.

Ensuring inclusive and equitable access to AI-driven agricultural innovations requires addressing the digital divide that exists between developed and developing regions. In the USA, efforts should focus on preventing the concentration of AI benefits among large-scale farmers. Policies and initiatives should promote knowledge-sharing, capacity building, and financial support for smaller farmers to adopt AI technologies. Collaboration between technology providers, government agencies, and farmers' organizations is essential to ensure a more inclusive and equitable agricultural sector. In Africa, the challenge is to overcome barriers such as limited access to technology, connectivity issues, and financial constraints. Future initiatives should prioritize the development of affordable, scalable technologies that cater to the needs of smallholder farmers. Collaborations with international organizations, NGOs, and private entities can play a crucial role in providing resources, expertise, and support to ensure that AI-driven innovations benefit farmers across diverse contexts.

The future of AI in agriculture should prioritize empowering smallholder farmers, who form the backbone of agriculture in many developing regions, including Africa. In the USA,

where larger farms dominate, inclusive practices involve extending the benefits of AI to smaller operators. This includes developing user-friendly interfaces, providing training programs, and fostering collaborations that recognize the needs and challenges faced by diverse farming communities. In Africa, the emphasis should be on creating solutions that empower smallholder farmers with actionable insights, real-time information, and decision-making tools. Mobile applications, SMS-based services, and community-driven initiatives can bridge information gaps and empower farmers to make informed choices. Inclusive access to AI innovations ensures that the benefits of increased productivity and sustainability are realized across all scales of agricultural production (Ezeigweneme *et al*., 2024; Mouchou *et al*., 2021; Lezoche, *et al*., 2020) [20, 42, 37].

In conclusion, the future outlook of AI in agriculture holds immense potential for transforming global food security. The comparative review of developments in the USA and Africa underscores the importance of tailored approaches, robust policy frameworks, and inclusive access to AI-driven innovations. By addressing the unique challenges of each region and fostering collaborations that bridge disparities, the agricultural sector can harness the power of AI to ensure a sustainable, resilient, and equitable future for food production on a global scale.

2.6 Conclusion

The comparative review of AI in agriculture in the USA and Africa has illuminated both the strides and challenges in integrating Artificial Intelligence into farming practices. In the USA, advanced technological infrastructure and resources have driven the adoption of AI, particularly in precision agriculture, climate resilience, and data-driven decision-making. Meanwhile, Africa, with its unique agricultural landscape dominated by smallholder farmers, is navigating challenges such as limited infrastructure, resource constraints, and the need for context-specific solutions. Key findings include the potential of AI to significantly impact global food security by enhancing productivity, climate resilience, and sustainable practices. In both regions, the need for tailored approaches that consider the specific challenges and characteristics of each agricultural landscape emerged as a central theme. While the USA focuses on refining existing AI applications, Africa is poised to benefit from innovations that empower smallholder farmers and address local challenges.

The transformative potential of AI in agriculture necessitates a collective call to action for sustainable and inclusive adoption. In the USA, the emphasis should be on ensuring that the benefits of AI are extended beyond large-scale farms, promoting inclusive practices that empower smaller operators. Collaborations between technology providers, policymakers, and farmers' organizations should prioritize knowledge-sharing, capacity building, and financial support to democratize access to AI technologies. In Africa, the call to action involves developing and deploying context-specific solutions that cater to the needs of smallholder farmers. Initiatives must focus on overcoming barriers such as limited access to technology, connectivity issues, and financial constraints. By fostering international collaborations and leveraging support from NGOs and private entities, Africa can accelerate the adoption of AI in agriculture, ensuring that the benefits reach even the most remote and resource-constrained regions.

The call to action extends to policymakers, urging the development of robust policy frameworks that address ethical considerations, data privacy, and fair access to AI-driven innovations. Policy initiatives should be inclusive, considering the diversity of farming practices and ensuring that the benefits of AI are shared equitably. By fostering an environment that encourages innovation while prioritizing the needs of local communities, policymakers play a crucial role in shaping the future of AI in agriculture. As the journey of integrating AI into agriculture unfolds, it is crucial to recognize ongoing research needs and areas for further exploration. Continued research is essential to refine existing AI applications, develop new technologies, and address emerging challenges. In the USA, research efforts should focus on optimizing precision agriculture practices, enhancing climate resilience, and advancing data analytics capabilities to meet the evolving needs of the farming sector.

In Africa, research endeavors must prioritize the development of affordable, scalable technologies that cater to the specific challenges faced by smallholder farmers. Tailored AI applications, coupled with ongoing research on climate-smart agriculture and inclusive technological solutions, will contribute to the sustainable adoption of AI in the diverse agricultural landscapes of the continent. Ongoing exploration should also consider the ethical implications of AI in agriculture, including issues related to data ownership, privacy, and the potential impact on employment in rural communities. Researchers play a pivotal role in guiding the ethical deployment of AI technologies, ensuring that the benefits align with societal values and contribute to the overall well-being of farmers and the agricultural sector.

In conclusion, the comparative review highlights the dynamic landscape of AI in agriculture, where technological advancements coexist with unique challenges. A sustainable and inclusive future for AI adoption in agriculture requires collaborative efforts, tailored approaches, and ongoing research to address the evolving needs of farmers globally. By embracing these principles, the agricultural sector can harness the full potential of AI to contribute to food security, sustainability, and the well-being of farming communities around the world.

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