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Determinants of rice farmers adaptive capacity to flooding for sustainable production in Benue State, Nigeria

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ABSTRACT

The study was conducted to ascertain the priority areas of agricultural practices for investment in Artificial Intelligence (AI) tools and services in the Enugu-Ezike agricultural zone, Enugu State, Nigeria. The objectives of the study were to: ascertain farmers' perception of A.I tools and services; ascertain priority areas of use of A.I tools and services; and ascertain specific activities in crop and livestock production for application of A.I tools and services. A multi-stage sampling procedure was used to select the sample size of 72 respondents. Data were collected using a structured interview schedule. The data were analysed using frequency, percentages, mean and standard deviation. The result on perception of A.I tools and services showed a grand mean score of 2.32. This meant that, putting all the variables together, there was a low perception of A.I tools and services by the respondents. The majority (78%) of the respondents prioritised the use of A.I tools and services in crop production. Of this number, a greater proportion (64.3%) of the respondents would like to apply A.I tools and services the most in root and tuber crop production. Also, all (100%) of this number would like to apply A.I tools and services the most in automated harvesting. However, for the few that prioritised animal production, the majority (62.5%) would want to use A.I in poultry production. Also, all (100%) would like to apply AI tools and services the most for security purposes. The study concluded that the farmers prioritised the use of A.I tools and services in crop production. The study recommended the need for targeted awareness and educational campaigns to enlighten farmers about A.I tools and services, their potential benefits, and applications in agriculture.

Keywords: Artificial Intelligence, Agriculture, Tools and Services

1. INTRODUCTION

Agriculture is essential for any society to feed its population. It plays a vital role in the economic growth of any country. In Africa, particularly in Nigeria, agriculture is a key sector that drives the economy. According National Bureau of Statistics (NBS), (2022), agriculture contributed about 26 per cent of the Nigerian Gross Domestic Product. However, the current state of Nigerian agriculture highlights the need for

more innovative solutions. Despite the contribution to the economy, Nigeria's agricultural sector faces many challenges which impact its productivity, such as high production cost, high post-harvest losses and low technology (Food and Agriculture Organisation [FAO], 2023). Besides, with the increase in population of over 221 million, and a fast yearly growth rate of 2.6 per cent, the predominant farming methods struggle to keep up with the population growth. Farmers are confronted with challenges such as poor quality seeds, limited labour, and the invasion of urbanisation on farmland (Coulibaly & Li, (2020). These challenges, among others, threaten the sustainability of the Nigerian food system.

Given the above challenges, there is a need to revolutionise Nigeria's agricultural system using advanced technologies. Already, there have been significant transformation in the agricultural sector in developed countries with the integration of Artificial intelligence systems. Artificial intelligence (AI) involves the use of robots, computers, and other machines with a human-like ability to reason and solve problems (McPherson, 2018). AI tools and services makes the attainment of smart agricultural objectives beyond the reach of human capabilities (Ali et al., 2025).

In agriculture, AI can be used to solve a wider range of issues, such as crop and soil monitoring, autonomous robots for crop harvests, precision spraying of crops with pests and diseases, prediction of the crop yield, price forecasts, and disease diagnostics (Talaviya et al., 2020). Artificial intelligence allows data collection from local image capture, aerial drones, and remote satellites to monitor crop and soil health. By harnessing the power of AI, farmers can optimise their operations, increase productivity, and reduce negative environmental impact. Moreover, it will ensure the continued availability of fresh, high-quality products for consumers around the world. The integration into agricultural practice can help farmers to access valuable insights from experts around the world (Kamilaris and Prenafeta-Boldu, 2018). In the Nigerian agricultural sector, the impact of AI goes beyond the farm itself; it makes access to agricultural knowledge accessible to individuals without formal agricultural education. It offers wide-ranging information on crop cultivation and livestock management, pest management, and farm automation thereby promoting sustainable farming practices (Talaviya et al., 2020).

A.I provides support to farmers and extension services. It enables precision farming through technologies like drones and sensors. These helps in optimising resource utilisation and crop yields (Jayasingh et al., 2024). Also, A.I tools like crop surveillance helps to detects diseases, pests, and nutrient deficiencies. A.I tools and services helps in overcoming the barriers of limited extension workers. Tools like Chatbots and virtual assistants provide instant access to agricultural information. Data analytics, language processing, and market analysis harness AI's power to make informed decisions, adapt to climate change, and improve farm management. AI supports training and education, ensuring farmers stay updated on best practices (Jayasingh et al., 2024).

In addition, AI is useful for reducing the impacts of climate change through resilient agricultural practices. For example, AI enables real-time monitoring and predictive analytics of environmental conditions. This makes it possible for early warning systems against climate-related risks, such as drought, floods, and extreme temperatures, and for timely and effective responses (Singh & Goyal, 2023).

Given that these technologies provide solutions, the successful incorporation of AI tools and services into various agricultural practices remains a function of the level of acceptance and willingness of local farmers to adopt and invest in AI-powered solutions. According to Takahashi & Gupta (2018), farmers may not be willing adopt A.I technologies due to fear of job displacement or lack of familiarity. The acceptance and integration of A.I technologies into the farming system hinges on the priority of the farmers. The farmers' priority is a major determinants of their willingness to invest. Current empirical studies on AI have focused on other areas. There seems to be limited empirical findings on the priority of farmers in the adoption of AI systems. For example, Javaid *et al.* (2023) focused on the potential applications of artificial intelligence in the agricultural sector. Chatterji *et al.* (2020) focused on Artificial Intelligence for digital agriculture. There seems to be a gap in the literature on priority areas of agricultural practice for investment in artificial intelligence tools and services. This study was designed to fill the empirical gap. Specifically, the study ascertained the farmers' perception of AI tools and services and the priority areas of agricultural practice for investment in Artificial Intelligence.

2. MATERIALS AND METHODS

The study was conducted in the Enugu-Ezike agricultural zone of Enugu State, Nigeria. The Zone is one of the six agricultural zones in the State. It comprised eight agricultural blocks, namely: Igbo Eze North Block I, Igbo Eze North Block II, Igbo Eze North Block III, Igbo Eze North Block IV, Igbo Eze South Block I, Igbo Eze South Block II, Udenu Block 1, and Orba Block (see figure 1). The population of the study consisted of all the farmers in the Enugu-Ezike agricultural zone. A multi-stage sampling procedure was employed to select the sample size. In the first stage, three agricultural blocks were selected randomly from the eight agricultural blocks in the zone. In the second stage, a random sampling techniques was used to select two circles in each of the selected blocks. This gave rise to 6 circles from

3 agricultural blocks. In the third stage, twelve farmers from the list of farmers in the area were randomly selected from each of the selected circles. Thus, giving a total sample size of seventy-two (72) for the study. The data for the study were collected using an interview schedule, and was administered using an Android application (Kobo Collect). This method of data collection is reliable, accurate, easy to manage and analyse. The Global Positioning System (GPS) location for each interview was obtained to ensure accuracy. The point of data collected (GPS) is presented in Figure 2.

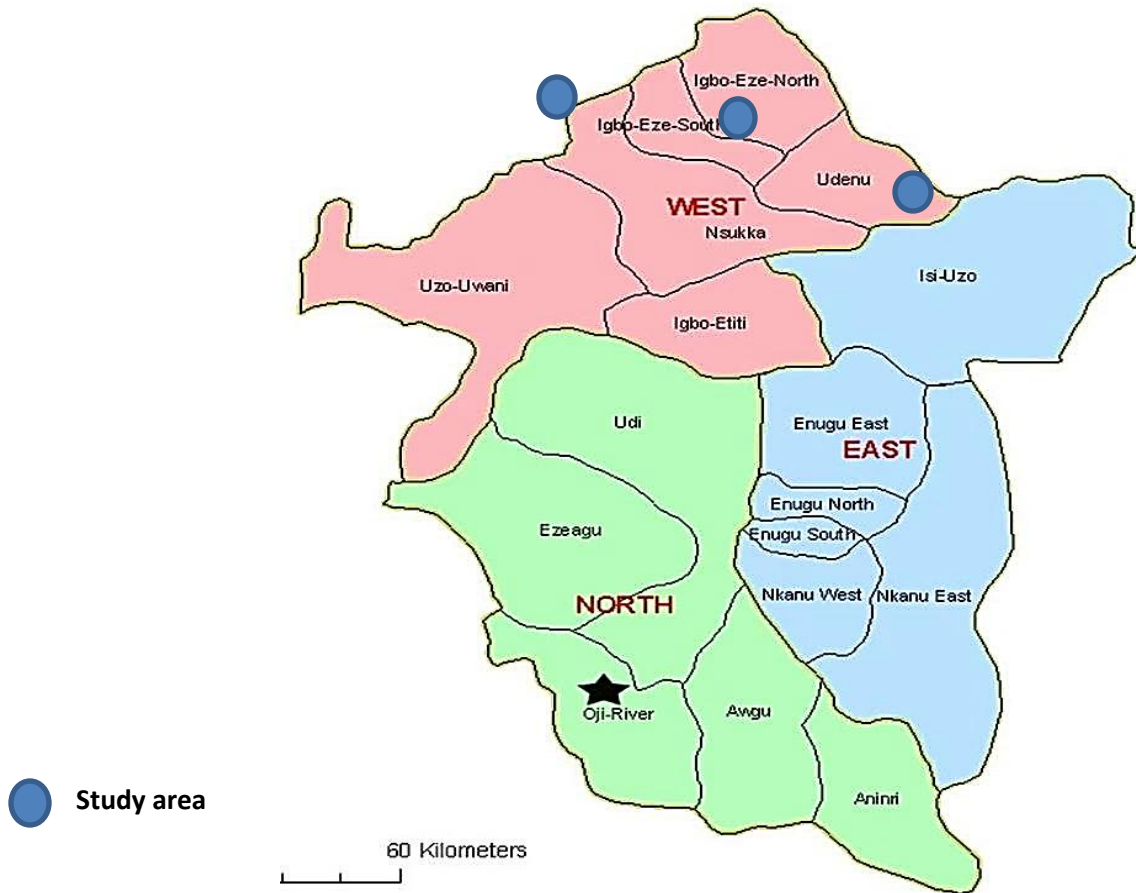


Figure 1: Map of Enugu state showing the study location

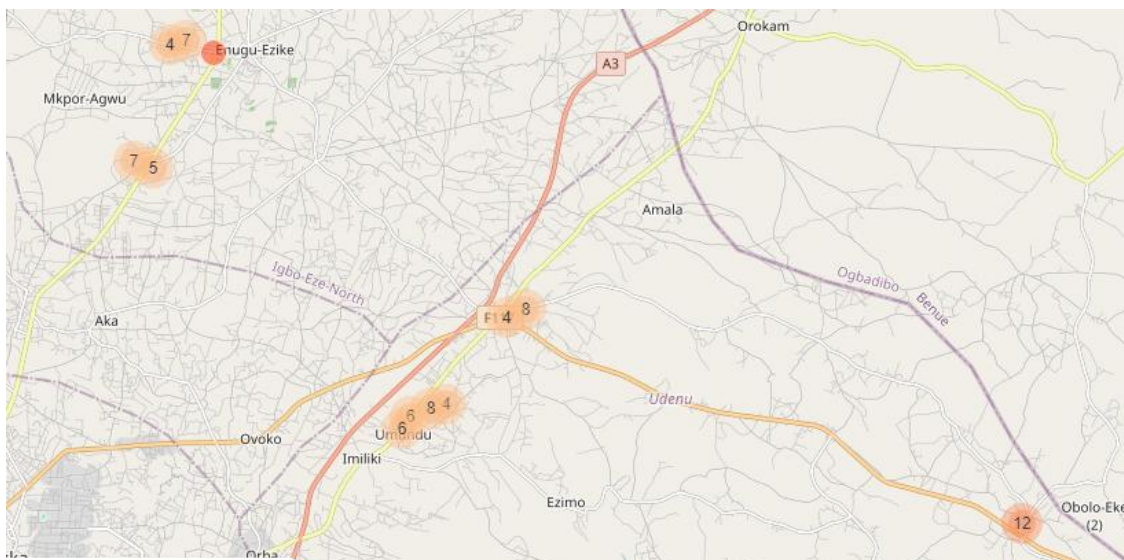


Figure 2: GPS locations of points of data collection

Data on the perception of AI tools and services were collected using a 4-point Likert-type scale. List of options were provided on a 4-point Likert-type scale of 1= Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree. The scale was summed up to 10 and was divided by 4 to give a mean score of 2.5. Variables with mean scores equal to 2.5 and above were considered as high perception of AI tools and services, while variables with mean scores below 2.5 were considered as low perception of AI tools and services.

To identify respondents' priority areas for the use of AI tools and services, a closed-ended question format was employed. Farmers were given multiple options when asked the first question of what their priority areas were for the use of AI tools and services. The options given were Crop production and Livestock production. The second question further identified their priority areas for each of the options. The area of crop production included: smart spraying, seed-sowing, etc., while the area of livestock production included: smart feeding, security/theft, etc. Variables were analysed, and presented using frequency, percentage, mean score and standard deviation.

3. RESULTS & DISCUSSION

Farmers' perception of AI tools and services

The result in Table 1 shows a grand mean score of $\bar{x}=2.32$. This implies that, putting all the variables together, there was a low perception of AI tools and services by the respondents. However, the results also shows that some variables had high positive perceptions like: AI tools and services will be a game-changer for farming activities ($\bar{x}=3.17$), AI can be used for all farm enterprise ($\bar{x}=3.14$), AI tools are numerous ($\bar{x}=3.13$), AI is imported from other countries ($\bar{x}=3.11$), AI tools are easy to handle ($\bar{x}=2.9$) and AI does not require human operators in the farm ($\bar{x}=2.61$). The majority of the farmers built their perception on AI after seeing videos like the automated harvester, sprayers and precision planting. The farmers observed the ease tasks were performed and perceived that AI is a game-changer in farming, and that it is easy to handle. Most of the tools the farmers saw were alien and foreign to them, and as such, they perceived that AI tools were imported from other countries. These findings corroborate previous empirical studies. For example, Ayodele *et al.*, (2025) found that AI tools support farmers' income improvement. Also, Bulus *et al.* (2021) reported that AI-driven marketing tools have the potential to strengthen smallholder farmers' bargaining power and financial outcomes.

The result in Table 1 also shows the variables with low perceptions of AI tools and services by the respondents. These include; AI is challenging to maintain ($\bar{x}=2.03$), purchasing AI can decrease farmers income significantly ($\bar{x}=2.03$), AI is difficult to use ($\bar{x}=1.99$), AI has been made for specific farmers ($\bar{x}=1.99$), AI is not operational in Nigeria ($\bar{x}=1.96$), AI is a technological scam ($\bar{x}=1.89$), AI has been designed to destroy our cultural and agricultural practices ($\bar{x}=1.81$), AI is produced for only lazy farmers ($\bar{x}=1.75$) and AI tools are cheap in the market ($\bar{x}=1.71$). A lot of factors might have influenced farmers' low perception. Many of these farmers believe that AI is a big machine that virtually does all the work on the farm. Given the cost of labour in the study area, the farmers perceived that any tool or service that will be able to do most of the work will cost much more than the current cost of labour. The perception that AI is a technological scam could be because most of these farmers have not seen the application of AI in real time. These perceptions contrast with the findings of previous studies like Ekperi *et al.* (2024) who found that there was a high perception that AI will disrupt the farming and cropping system. Also, according to Mohr and K uhl (2021), there were high societal fears about AI diminishing the value of human labour among farming populations.

Table 1: Farmers' perception of AI tools and services

Variables	Mean (\bar{x})	Standard deviation
I consider AI tools and services to be a game-changer for farming activities	3.1667	0.37529
AI can be used for all farm enterprises	3.1389	0.53879
AI tools are numerous	3.1250	0.40897
AI is imported from other countries	3.1111	0.35823
AI tools are easy to handle	2.8889	0.42972
AI does not require human operators on the farm	2.6111	0.49092
AI is difficult to maintain	2.0278	0.41016
Purchasing AI can decrease farmers' income significantly	2.0278	0.44317
AI is difficult to use	1.9861	0.42767
AI has been made for specific farmers	1.9861	0.31368

AI is not being used in Nigeria	1.9583	0.35355
AI is a technological scam	1.8889	0.31648
Agricultural products produced with AI are harmful to the body	1.8611	0.34826
AI has been designed to destroy our cultural and agricultural practices	1.8056	0.39855
AI has been produced for only lazy farmers	1.7500	0.49647
AI tools are cheap on the market	1.7083	0.48752

High perception $\bar{x} > 2.5$ Low perception $\bar{x} < 2.5$

Priority areas for the use of AI tools and services

The result in Figure 3 shows that the majority (78%) of the respondents prioritise crop production as the area they would like to use AI tools and services, while 22% prioritise livestock production. The reason for this could be the nature of the farming enterprise. Farmers find crop production more demanding and are more likely to adopt AI solutions to address specific challenges in this area. The high priority given to crop production may be due to the potential of AI to improve crop yields, reduce losses and promote sustainable practice. Crop production in the area is often more susceptible to environmental factors such as weather, pests and diseases. This makes the use of AI solutions more appealing. Another reason was that the majority of the respondents were into crop farming. Crops like cocoyam, cassava and pepper were their major farming enterprise. This disparity in the priority areas of use of AI tools and services between crop and livestock production may be due to the differences in farming practices. Further enquiries on specific areas of crop and livestock enterprise that the farmers would like to use AI were made, and the results are presented in Figure 4, Table 2, Figure 5 and Table 3.

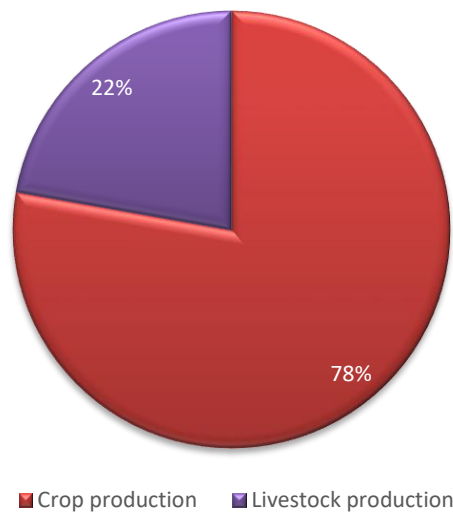


Figure 3: Priority areas for use of AI tools and services

Priority areas of use of AI tools and services in crop production

The result in Figure 4 shows that (64.2%) of the respondents would like to apply AI tools and services the most in root and tuber crop production, 30.4% in vegetable farming, and 5.4% in grain production. This distribution is influenced by the types of crops farmers in the area are involved in. Root and tuber crops such as cassava, yam, potatoes, cocoyam, tree leaf yam and water yam were the predominant root and tuber crops in the area. Vegetable farming, particularly leafy and fruit vegetables like pumpkin leaves, scent leaves, eggplant leaves and amaranthu. On the other hand, fruit vegetables like tomatoes, cucumbers and okra, were predominantly cultivated in the area. Conversely, grain production was not common among the respondents. This implies that farmers in the area were willing to prioritize the use of AI in the area of farming they are predominantly involved in. this result aligns with the findings of Kamilaris and Prenafeta-Boldu (2018) who reported that farmers are more likely to adopt new technologies in areas where they have existing expertise and investment. However, within these areas of crop enterprise, there were specific activities that the crop farmers would like to use AI to accomplish. This is presented in Table 2.

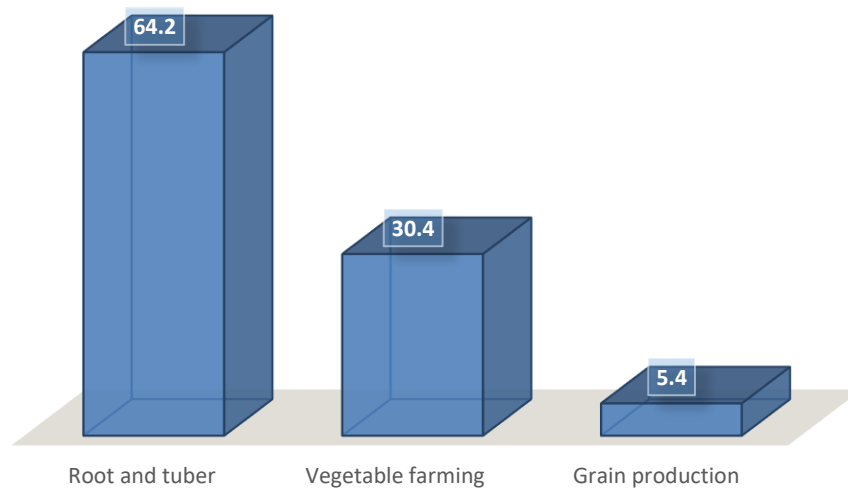


Figure 4: Priority areas for the use of AI tools and services in crop production

Activities in crop production for the application of AI tools and services

The result in Table 2 shows that all (100%) of the respondents who prioritised crop production chooses automated harvesting as activities to use A.I tools and services. Harvesting, especially for root and tuber crops, is one of the most strenuous tasks in farming. Most times, a significant part of the produce is left unharvested because of the labour involved. It is not surprising that farmers will want to try a technology that will ease the stress of harvesting and, at the same time, increase the quality and quantity of the harvest. Furthermore, the result in Table 2 shows that 96.4% of the respondents prioritise the application of AI for weeding operations. Manual weeding is labour intensive and strenuous. It involves bending over for long periods, pulling out weeds by hand or using hand tools. The use A.I powered weed detection can significantly reduce the physical strain associated with this activity. The rest of the result in Table 2 shows that 94.6% prioritise the application of AI in pest and disease management, crop/soil monitoring, maturity detection, crop yield prediction, smart spraying, and seed sowing. This is also not surprising because these activities are often labour-intensive, time-consuming and physically strenuous.

Table 2: Priority areas of application of AI tools and services in crop production

Priority areas of application of AI tools and services in crop production	Frequency	Percentage
Automated harvesting	56	100
Weeding	54	96.4
Irrigation	53	94.6
Pest and disease detection/management	53	94.6
Crop quality assessment	53	94.6
Crop/soil monitoring	53	94.6
Maturity detection	53	94.6
Crop yield prediction	53	94.6
Smart spraying	53	94.6
Seed sowing	53	94.6

Source: Field survey, 2024

Priority areas for the use of AI tools and services in livestock production

The result in Figure 5 shows that the majority (62.5%) of the respondents would like to apply AI tools and services the most in raising poultry production. This is followed by 37.5% in piggery production. The reason for this is because many of the livestock farmers were involved in poultry production. Another reason could be the technicalities involved in raising poultry. There is a higher morbidity in

poultry farming than piggery; as such, farmers will want to use technologies that can detect early signs of diseases to avoid the high rate of mortality. However, result of specific activities in livestock for investment A.I are presented in Table 3.

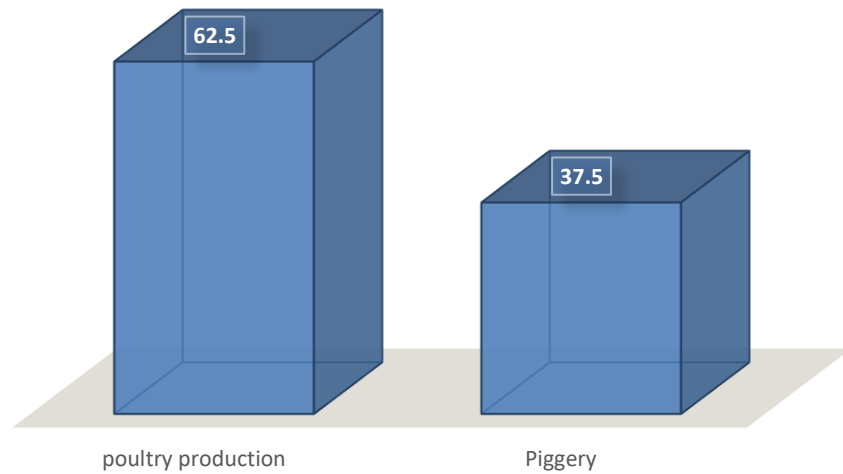


Figure 5: Priority areas of use of AI tools and services in livestock production

Activities in livestock production for the application of AI tools and services

The result in Table 3 shows that all (100%) of the respondents who prioritised animal production choses security/theft issue as activity to apply A.I tools and services. Manually monitoring livestock/farm security threats and potential theft can be physically demanding. AI-powered surveillance systems, motion detectors, and drones can automate this process, reducing the physical strain on farmers. Again, 93.75% of the farmers who prioritise livestock production would like to apply AI in environmental monitoring/sanitation. Maintaining proper environmental conditions and sanitation in livestock facilities can be a labour-intensive task, involving manual cleaning, ventilation adjustments, and constant monitoring. AI-based sensors and automation systems can streamline these processes, minimising the physical effort required. Furthermore, the result in Table 3 shows that 87.5% of the farmers who prioritise livestock production would like to apply AI in health monitoring, smart feeding, disease detection, vaccination, water management, automated sorting and grading, and reproduction management. This is not surprising because these activities are often labour-intensive, time-consuming and physically strenuous.

Table 3: Priority areas of application of AI tools and services in livestock production

Priority areas of application of AI tools and services in livestock production	Frequency	Percentage
Security/theft management	16	100
Environmental monitoring/sanitation	15	93.75
Health monitoring	14	87.5
Smart feeding	14	87.5
Disease detection	14	87.5
Vaccination	14	87.5
Water management	14	87.5
Automated sorting and grading	14	87.5
Reproduction management	14	87.5
Egg collection for poultry	13	81.25

4. CONCLUSION

The potential of artificial intelligence to reshape agriculture is undeniable. It is an invaluable platform for the future of farming. However, there is a low perception of Artificial Intelligence (AI) tools and services in the study area, and the majority of respondents prioritised the use of AI tools and services in crop production. The farmers would like to use AI in activities like harvesting in crop

farming and in security/theft management for livestock farming.

Recommendation

Government, through the ministries of agriculture, science and technology, should conduct targeted awareness and educational campaigns to enlighten farmers about AI tools and services. Government and stakeholders in agriculture should establish demonstration farms/ pilot projects that will showcase the successful implementation and benefits of AI tools and services. Government should provide financial incentives and subsidies for farmers to encourage them to adopt AI-based technologies and practices.

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Author's Contribution

APO (45%) conceptual the idea, coordinated the process, reviewed the analysis

UIO (30%) developed the content and collected the data

ABN (10%) assisted in manuscript development

NGC (15%) assisted in content development and review of the analysis

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Conflict of interest

The authors declare that they have no conflicts of interests, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Ethical approval

The study was done in conformity with ethical guidelines. Participation was entirely voluntary, and all respondents provided informed consent. The participants' anonymity and confidentiality were ensured, and the data obtained were utilized purely for the study. The ethical guidelines for Human Subjects are followed in the study.

Informed consent

Oral informed consent was obtained from individual participants included in the study.

Data availability

All data associated with this study are presented in the paper.

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