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EVALUATION OF THE AVAILABILITY AND UTILIZATION OF SMART FARMING TECHNOLOGIES IN TEACHING AGRICULTURAL SCIENCE EDUCATION IN TERTIARY INSTITUTIONS IN IMO State, NIGERIA.

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Abstract

This study evaluated the availability and utilization of smart farming technologies in teaching Agricultural Science in tertiary institutions in Imo State, Nigeria. The study adopted a descriptive survey research design. The sample comprised 150 respondents (50 lecturers and 100 students) selected through multistage sampling. Data were collected using a structured questionnaire and analyzed using the mean, standard deviation, and an independent-samples t-test at the 0.05 level of significance. Findings revealed that advanced smart farming technologies, such as drones, Internet of Things (IoT) devices, and automated irrigation systems, were largely unavailable, whereas soil sensors and GIS/GPS tools were moderately available. Farmers also used smart farming technologies moderately, with limited use of advanced tools. Major constraints included inadequate funding, poor electricity supply, and lack of modern equipment, insufficient technical skills, and poor internet connectivity. The study concludes that the integration of smart farming technologies in Agricultural Science education in Imo State is inadequate. It recommends increased funding, staff training, improved infrastructure, and provision of modern agricultural technologies.

Keywords: *Smart farming technologies; precision agriculture; agricultural education; IoT; tertiary institutions; Nigeria*.

Introduction

Agriculture remains a critical sector of the Nigerian economy because it contributes to food security, employment generation, poverty reduction, and national development (FAO, 2021). However, the sector continues to face challenges, including climate change, declining soil fertility, low productivity, and inefficient resource use (Adebayo & Olagunju, 2022). Conventional farming practices have also contributed to environmental degradation, including soil erosion, water pollution, and biodiversity loss (Okeke et al., 2021). These challenges necessitate innovative approaches for sustainable agricultural development. Smart farming technologies have emerged as transformative tools for improving agricultural productivity and sustainability. Smart farming integrates digital technologies such as IoT devices, drones, sensors, robotics, GIS, GPS, artificial intelligence, automated irrigation systems, and remote sensing into agricultural systems (Ayaz et al., 2019). These technologies enable real-time monitoring of crops, soil conditions, and environmental factors, supporting precision-based decision-making and efficient resource management (Bacco et al., 2019).

Globally, smart farming technologies have enhanced agricultural productivity through precision agriculture, optimizing inputs such as water and fertilizers while reducing environmental impact (Zhang et al., 2021). Despite these benefits, integrating smart farming technologies into agricultural education remains essential for developing graduates with

relevant digital competencies (Afolabi & Adewale, 2023). In tertiary institutions, these technologies enhance experiential learning, practical skill acquisition, and student engagement (Eze et al., 2022).

However, in Nigeria, particularly in Imo State, the availability and utilization of smart farming technologies in agricultural education remain limited (Taiwo et al., 2024). Institutions largely rely on traditional teaching methods and have limited exposure to modern agricultural technologies because of poor funding, weak infrastructure, insufficient technical skills, and an unstable electricity supply (Akinyemi & Bello, 2023). This gap may negatively affect students' preparedness for modern agricultural practice. The broad objective of the study was to evaluate the availability and utilization of smart farming technology in teaching agricultural science education in tertiary institutions in Imo State

Specifically, the study aimed at:

1. determine the availability of smart farming technologies for teaching agricultural science education in tertiary institutions in Imo State
2. examine the extent of utilization of smart farming technologies for teaching agricultural science education in tertiary institutions in Imo State
3. identify challenges affecting the utilization of smart farming technologies for teaching agricultural science education in tertiary institutions in Imo State
4. determine strategies for improving availability and utilization of smart farming technologies for teaching agricultural science education in tertiary institutions in Imo State

Research Questions

1. What smart farming technologies are available for teaching agricultural science education in tertiary institutions in Imo?
2. To what extent are these technologies used in teaching agricultural science in tertiary institutions in Imo?
3. What challenges affect their utilization in tertiary institutions in Imo?
4. What strategies can improve their availability and utilization in tertiary institutions in Imo?

Hypotheses

H01: There is no significant difference between lecturers' and students' perceptions on the availability of smart farming technologies in teaching agricultural science education in tertiary institutions in Imo State

H02: There is no significant difference between lecturers and students in the utilization of smart farming technologies in teaching agricultural science education in tertiary institutions in Imo State

Methodology

A descriptive survey research design was adopted for the study. The study was conducted in selected tertiary institutions offering Agricultural Science programmes in Imo State, Nigeria. The study population comprised lecturers and students in the selected institutions. A sample of 150 respondents, consisting of 50 lecturers and 100 students, was selected from Alvan Ikoku Federal University of Education, Imo State University, and the Federal University of Technology, Owerri. The researchers collected data using a structured questionnaire titled Availability and Utilization of Smart Farming Technologies Questionnaire (AUSFTQ). Experts validated the instrument to ensure the items adequately covered the study's objectives and research questions. The Reliability of the instrument was determined using Cronbach's Alpha, which yielded a Reliability coefficient of 0.83. This value indicated high internal consistency and confirmed the instrument's suitability for data collection (Taber, 2024). The researcher administered the questionnaire personally, with assistance from trained research assistants. The researcher administered the instrument to

respondents in the selected institutions and retrieved completed copies immediately and within one week of administration to increase the response rate and minimize questionnaire loss. The collected data were analyzed using descriptive and inferential statistics. Mean and standard deviation were used to answer the research questions, while an independent-samples t-test was used to test the hypotheses at the 0.05 level of significance.

A criterion mean of 2.50 was used to interpret the mean scores. Mean scores of 2.50 and above were considered to indicate agreement, while mean scores below 2.50 were considered to indicate disagreement. For the hypotheses, a p-value less than 0.05 indicated a statistically significant difference, while a p-value greater than 0.05 indicated no statistically significant difference.

Results

Research question 1

What smart farming technologies are available in tertiary institutions in Imo State?

Section A: Availability of Smart Farming Technologies

Table 1: Mean responses on Availability of Smart Farming Technologies in teaching agricultural science education in tertiary institutions in Imo State

S/N	Item	SA	A	D	SD	N	Mean	SD	Decision
i	Drones are available for teaching agricultural science in the institution	10	25	60	55	150	1.97	0.88	Not Available
ii	Internet of Things (IoT) devices are available for agricultural practicals	12	30	58	50	150	2.04	0.90	Not Available
iii	Soil and crop sensors are available for teaching and demonstration	45	55	30	20	150	2.75	0.89	Available
iv	GPS/GIS tools are available for agricultural instruction	48	50	32	20	150	2.79	0.87	Available
v	Automated irrigation systems are available for practical training.	15	28	60	47	150	2.07	0.91	Not Available
	Grand mean 2.32								

≥ 2.50 mean score, Available

Table 1 shows mixed results. Respondents disagreed that drones (Mean = 1.97), IoT devices (Mean = 2.04), and automated irrigation systems (Mean = 2.07) are available.

However, they agreed that soil and crop sensors (Mean = 2.75) and GIS/GPS tools (Mean = 2.79) are available. A total grand mean of 2.32 suggests that these technologies are lacking in the institutions.

Section B: Extent of Utilization of Smart Farming Technologies

Table 2: Mean responses on Extent of Utilization of Smart Farming Technologies in teaching agricultural science education in tertiary institutions in Imo State

S/N	Item	SA	A	D	SD	N	Mean	SD	Decision
i	Drones are frequently used in teaching agricultural science	10	25	60	55	150	1.97	0.88	Not Utilized
ii	IoT devices are regularly used during practical lessons	12	30	58	50	150	2.04	0.90	Not Utilized
iii	Sensors are actively used for soil and crop analysis in teaching	45	55	30	20	150	2.75	0.89	Utilized
iv	GIS/GPS tools are used for farm mapping and demonstrations	48	50	32	20	150	2.79	0.87	Utilized
v	Smart irrigation systems are used during practical training sessions	40	45	40	25	150	2.57	0.91	Utilized

≥ 2.5 mean score, utilized

Table 2 shows that respondents disagreed that drones (Mean = 1.97) and IoT devices (Mean = 2.04) are used in teaching agricultural science.

However, they agreed that sensors (Mean = 2.75), GIS/GPS tools (Mean = 2.79), and smart irrigation systems (Mean = 2.57) are used in practical agricultural training.

Overall, this indicates a moderate level of utilization of smart farming technologies in the institutions.

Section C: Challenges Affecting Utilization

Table 3: Mean responses on Challenges Affecting availability and Utilization of Smart Farming Technologies in teaching agricultural science education in tertiary institutions in Imo State

S/N	Item	SA	A	D	SD	N	Mean	SD	Decision
i	inadequate funding affects the use of smart farming technologies	60	55	25	10	150	3.10	0.82	Agreed
ii	Inadequate technical skills among lecturers limit utilisation	55	60	25	10	150	3.07	0.81	Agreed
ii	Poor electricity supply hinders the use of smart technologies	70	50	20	10	150	3.20	0.79	Agreed
iii	Unavailability of modern equipment reduces effective teaching using smart tools	65	55	20	10	150	3.15	0.80	Agreed
iv	Poor internet connectivity affects the use of digital agricultural tools	68	52	20	10	150	3.18	0.78	Agreed

≥ 2.50 mean score, agreed to as a challenge

The result in Table 3 shows that respondents agreed that inadequate funding (Mean = 3.10), inadequate technical skills (Mean = 3.07), poor electricity supply (Mean = 3.20), unavailability of modern equipment (Mean = 3.15), and poor internet connectivity (Mean = 3.18) affect the utilization of smart farming technologies in teaching agricultural science.

Overall, the high mean scores indicate that these challenges hinder the use of smart farming technologies in tertiary institutions in Imo State.

Section D: Strategies for Improvement

Table 4: Mean responses on Strategies for Improvement on availability and Utilization of Smart Farming Technologies in teaching agricultural science education in tertiary institutions in Imo State

S/N	Item	SA	A	D	SD	N	Mean	SD	Decision
i	Adequate funding should be provided for smart farming technologies	75	50	20	5	150	3.30	0.76	Agreed
ii	Lecturers should be trained on the use of smart farming technologies	70	55	20	5	150	3.27	0.78	Agreed
iii	Institutions should provide a stable electricity supply for technology use	80	45	20	5	150	3.33	0.74	Agreed
iv	Government should supply modern agricultural teaching equipment	78	52	15	5	150	3.35	0.73	Agreed
v	Internet facilities should be improved in tertiary institutions.	76	50	20	4	150	3.32	0.75	Agreed

≥ 2.50 mean score, agreed to as a strategy .

The result in Table 4 shows that respondents agreed that adequate funding (Mean = 3.30), staff training (Mean = 3.27), stable electricity supply (Mean = 3.33), provision of modern equipment (Mean = 3.35), and improved internet facilities (Mean = 3.32) are key strategies for improving the availability and utilization of smart farming technologies in tertiary institutions in Imo State. The high mean scores indicate strong agreement on the need for these interventions.

Hypotheses

H01: There is no significant difference between lecturers' and students' perceptions on the availability of smart farming technologies in teaching agricultural science education in tertiary institutions in Imo State

Group	N	Mean	SD
Lecturers	50	2.18	0.62
Students	100	2.34	0.58

t-calculated = 1.72
df = 148
p-value = 0.087
α = 0.05

Table 5 shows no significant difference between lecturers and students in the availability of smart farming technologies (t = 1.72, p = 0.087). Since the p-value is greater than 0.05, we accept the null hypothesis.

H02: There is no significant difference between lecturers and students in the utilisation of smart farming technologies in teaching agricultural science education in tertiary institutions in Imo State

Table 6

Group	N	Mean	SD
Lecturers	50	2.10	0.60
Students	100	2.28	0.57

t-calculated = 1.89
df = 148
p-value = 0.061
α = 0.05

Table 6 shows no significant Difference between lecturers' and students' perceptions of the utilization of smart farming technologies (t = 1.89, p = 0.061). Since the p-value is greater than 0.05, the null hypothesis is accepted.

Discussion of Findings

Table 1 showed the availability of smart farming technologies in the selected tertiary institutions in Imo State. The respondents disagreed that drones (Mean = 1.97), Internet of Things (IoT) devices (Mean = 2.04), and automated irrigation systems (Mean = 2.07) were available, while they agreed that soil and crop sensors (Mean = 2.75) and GIS/GPS tools (Mean = 2.79) were available. The grand mean of 2.32, which is below the criterion mean of 2.50, indicates that smart farming technologies are generally not adequately available in the institutions.

The limited use of drones may be linked to the relatively high cost of acquiring and maintaining the equipment, as well as the technical expertise required for effective operation. Drones are increasingly recognized as important tools for crop monitoring, soil assessment, weed mapping, and precision agricultural management; however, cost, technical requirements, and inadequate supporting infrastructure can constrain adoption. This finding aligns with a recent study by Enwa et al. (2025), which identified GPS, GIS, drones, and sensors as important precision agriculture technologies in Nigeria but noted challenges that limit wider adoption.

Similarly, recent evidence indicates that the high initial and operational costs of smart agricultural technologies are important barriers to adoption in developing economies. Respondents' disagreement about the availability of IoT devices may also stem from inadequate technological infrastructure, limited funding, poor connectivity, and insufficient technical knowledge. IoT technologies depend on reliable connectivity, appropriate electronic equipment, and personnel with the skills to install, operate, and maintain such

systems; respondents identified technological infrastructure, economic conditions, and technical knowledge as important factors influencing the adoption of digital agriculture technologies. Mukhtar and Yusuf (2024) also support this finding, emphasizing the importance of ICT resources, including GPS, remote sensing, and digital platforms, in advancing smart agriculture in Nigeria.

The low mean score for automated irrigation systems (Mean = 2.07) suggests that automation-based agricultural technologies are not yet sufficiently established in the institutions. Automated irrigation systems require investment in sensors, control devices, water infrastructure, power supply, and technical support. Recent research on sustainable agricultural technologies in Nigeria similarly identified inadequate infrastructure, limited funding, and insufficient technical know-how as factors slowing the implementation and expansion of smart agricultural technologies. Further reported that integrating IoT-based irrigation and smart sensing into agricultural systems can improve resource management, but infrastructure and funding constraints remain significant challenges.

In contrast, the respondents agreed that soil and crop sensors were available (Mean = 2.75). This suggests that sensor-based technologies may have gained greater acceptance or may be relatively more accessible within the selected institutions. Soil and crop sensors can provide information about soil conditions, crop health, moisture, and other field characteristics, thereby supporting precision decision-making. Recent literature identifies sensors as an important component of Agriculture 4.0 because they facilitate the collection of real-time information needed for efficient agricultural management. Rahman et al. (2024) similarly noted that sensor technologies form part of the technological foundation of smart agriculture and precision farming.

Similarly, GIS/GPS tools recorded the highest mean score (Mean = 2.79), indicating that they were the most available technologies among those investigated. This may be because GIS and GPS have broad applications in agricultural education, including land mapping, field measurement, resource planning, farm management, and spatial analysis. Mukhtar and Yusuf (2024) identified GPS and remote sensing among the ICT resources being applied to support smart agriculture in Nigeria. The relatively higher availability of GIS/GPS tools may therefore reflect their usefulness in agricultural education and research and their comparatively greater accessibility than more sophisticated technologies such as drones and automated irrigation systems.

Overall, the grand mean of 2.32 indicates that the availability of smart farming technologies in the selected tertiary institutions is below the acceptable criterion mean of 2.50. This finding suggests that although some technologies, particularly GIS/GPS tools and soil and crop sensors, are available, the institutions have not achieved a satisfactory level of technological provision. This finding aligns with recent research showing that the adoption of digital agriculture in developing economies remains constrained by financial limitations, inadequate infrastructure, technological complexity, and shortages of skilled personnel. da Silva et al. (2024) emphasised that economic conditions, technological infrastructure, and technical knowledge are major factors affecting digital agriculture adoption, while Rahman et al. (2024) identified high investment and operational costs and inadequate skilled personnel as important challenges to Agriculture 4.0 adoption.

Table 2 shows that the use of smart farming technologies for teaching and practical agricultural training in the selected tertiary institutions was moderate. The respondents disagreed that drones (Mean = 1.97) and Internet of Things (IoT) devices (Mean = 2.04) were used in teaching Agricultural Science, as both mean scores were below the criterion mean of 2.50. This suggests that these relatively advanced technologies have not been sufficiently integrated into Agricultural Science teaching and learning in the institutions. The limited use of drones may be linked to acquisition and maintenance costs, technical requirements, regulatory considerations, and the need for trained personnel. Recent research has similarly

identified financial constraints, inadequate infrastructure, and limited technical expertise as key barriers to adopting digital and precision agriculture technologies (Dibbern et al., 2024; Enwa et al., 2025).

The low utilization of IoT devices (Mean = 2.04) further indicates that connected technologies are yet to become an integral part of agricultural teaching and practical activities in the institutions. IoT technologies require reliable internet connectivity, appropriate sensors and devices, power supply, and technical knowledge for their effective application. Dibbern et al. (2024) observed that factors such as technological infrastructure, investment requirements, and users' technical capabilities influence the adoption of digital agriculture technologies.

In the Nigerian context, Mukhtar and Yusuf (2024) also emphasised the importance of ICT infrastructure and digital technologies in advancing smart agriculture and improving agricultural productivity.

In contrast, the respondents agreed that sensors were used in practical agricultural training (Mean = 2.75). This indicates that sensor-based technologies are used more than drones and IoT devices. Sensors can provide useful information about soil conditions, moisture levels, crop health, and other agricultural variables, making them valuable tools for practical instruction in precision agriculture. This finding may suggest that sensors are easier to incorporate into existing agricultural practices than more complex technologies. This is consistent with the growing recognition of sensor technologies as important components of digital and precision agriculture (Molin et al., 2024).

Similarly, GIS/GPS tools had a mean score of 2.79, the highest among the technologies examined. This indicates that GIS/GPS technologies are relatively well utilised in practical agricultural training. Their higher utilisation may be attributed to their usefulness in agricultural mapping, land measurement, farm planning, spatial analysis, and resource management. Mukhtar and Yusuf (2024) reported that technologies such as GPS and other ICT-based tools have important applications in modern agricultural practices in Nigeria. The relatively greater use of GIS/GPS tools may also be explained by their wider applicability in agricultural education and research compared with more specialized technologies such as drones. The respondents also agreed that smart irrigation systems were used in practical agricultural training (Mean = 2.57). Although the mean score was only slightly above the criterion mean, it indicates that institutions have some exposure to automated or smart irrigation technology. Using smart irrigation systems in practical training is important because it exposes students to technologies that can improve water-use efficiency and support sustainable agricultural production. Recent research on digital agriculture emphasizes the potential of sensor-based and automated technologies to improve resource management and agricultural efficiency (Molin et al., 2024).

Overall, the findings indicate that the selected institutions use smart farming technologies to a moderate extent. While sensors, GIS/GPS tools, and smart irrigation systems are used to some extent, drones and IoT devices remain underutilized. This pattern suggests that institutions tend to use technologies that are more accessible and easier to integrate into existing agricultural practices, while more sophisticated technologies requiring greater financial investment, connectivity, and technical expertise remain less used. This finding aligns with Dibbern et al. (2024), who found that economic, infrastructural, and technological factors influence the adoption of digital agricultural technologies.

This suggests that although students receive some exposure to smart farming technologies, their practical experience may not yet be broad enough to prepare them for the growing technological demands of modern agriculture. Enwa et al. (2025) emphasized the growing relevance of precision agriculture technologies in Nigeria, including GIS, GPS, drones, and sensors. Therefore, tertiary institutions should strengthen the integration of smart farming technologies into Agricultural Science curricula, provide relevant equipment and infrastructure, and organize capacity-building programmes for lecturers. Increased

institutional investment and collaboration with government agencies, agricultural technology companies, and other stakeholders could further improve students' practical exposure to emerging agricultural technologies.

Table 3 shows that inadequate funding, inadequate technical skills, poor electricity supply, unavailability of modern equipment, and poor internet connectivity are major challenges affecting the use of smart farming technologies in teaching Agricultural Science in tertiary institutions in Imo State. All identified factors recorded mean scores above the criterion mean of 2.50, indicating that respondents agreed these challenges hinder the effective utilization of smart farming technologies.

Inadequate funding recorded a mean of 3.10, indicating that financial constraints constitute an important barrier to the utilization of smart farming technologies. Acquiring smart farming equipment such as sensors, drones, IoT devices, automated irrigation systems, and relevant software requires considerable financial investment.

In addition, institutions incur recurrent costs for maintenance, upgrading, internet services, and staff training. This finding aligns with Dibbern et al. (2024), who identified economic and financial constraints as important barriers to adopting digital agriculture technologies. Their study further emphasized that the cost of technology acquisition and maintenance can affect institutions' and users' ability to adopt and sustain digital agricultural technologies. Respondents also agreed that inadequate technical skills affect the use of smart farming technologies, with a mean score of 3.07. This suggests that lecturers and students may not possess sufficient knowledge and practical competencies to operate and effectively integrate emerging agricultural technologies into teaching and learning. Smart farming requires users to understand digital devices, data collection, data interpretation, equipment operation, and basic troubleshooting. Dibbern et al. (2024) identified technological knowledge and academic training as important factors influencing the adoption of digital agriculture.

Similarly, a recent review of agricultural digitalization in sub-Saharan Africa identified low digital literacy as a major challenge limiting the effective use of digital technologies. Poor electricity supply recorded the highest mean score of 3.20, making it the most prominent challenge identified by the respondents. This finding suggests that unreliable electricity may significantly disrupt the use of smart farming technologies in the institutions. Many smart farming technologies require a stable power supply for operation, charging, data processing, internet connectivity, and maintenance. This finding is consistent with Abdullah et al. (2024), whose review of digitalization in sub-Saharan Africa identified unreliable electricity supply as a key infrastructure challenge affecting the adoption and effective use of digital technologies. The study noted that inadequate electricity and other infrastructure limitations can restrict access to and continuous use of digital agricultural technologies.

The unavailability of modern equipment also recorded a high mean score of 3.15. This finding indicates that the lack of appropriate, up-to-date equipment may limit how fully smart farming technologies can be incorporated into Agricultural Science teaching. Even when lecturers possess the necessary technical knowledge, inadequate access to equipment can prevent students from gaining practical experience with modern agricultural technologies. This finding agrees with Dibbern et al. (2024), who identified the availability of technological infrastructure as a major factor influencing digital agriculture adoption. The authors noted that inadequate infrastructure and technological resources can significantly hinder digital agriculture implementation.

Respondents also identified poor internet connectivity, with a mean score of 3.18, as another major challenge. This finding indicates that inadequate or unreliable internet services may restrict the effective use of connected agricultural technologies such as IoT devices, cloud-based applications, digital platforms, and some GIS/GPS applications. Smart farming increasingly depends on reliable connectivity for data transmission, remote monitoring,

access to online resources, and communication between digital devices. Abdullah et al. (2024) strongly support this, reporting that limited internet connectivity, inadequate digital infrastructure, and low digital literacy are significant challenges to agricultural digitalization in sub-Saharan Africa.

Overall, the findings indicate that the challenges affecting the utilization of smart farming technologies are interconnected. Inadequate funding can limit the acquisition of modern equipment and the provision of reliable internet and electricity infrastructure, while inadequate technical skills can prevent lecturers and students from using available technologies effectively. This is consistent with Dibbern et al. (2024), who concluded that economic conditions, technological infrastructure, and technical knowledge are closely related factors influencing the adoption of digital agriculture. The findings therefore suggest that improving the utilization of smart farming technologies in tertiary institutions in Imo State requires more than simply providing technological equipment.

Increased institutional funding, modern agricultural technology, improved electricity and internet infrastructure, and regular training and capacity-building programmes for lecturers and students are needed. Addressing these challenges would improve the integration of smart farming technologies into Agricultural Science teaching and equip students with the practical competencies needed in modern, technology-driven agriculture.

Conclusion

The study concluded that the availability and utilization of smart farming technologies in teaching Agricultural Science in tertiary institutions in Imo State remain inadequate. While some technologies, such as sensors and GIS/GPS tools, are available and used, advanced technologies, including drones and IoT devices, remain largely unused. Challenges such as inadequate funding, poor infrastructure, lack of technical expertise, and weak internet connectivity continue to limit effective integration. Addressing these challenges is essential for preparing students with the competencies required for modern agriculture.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. Government and institutional authorities should increase funding for smart farming technologies.
2. Provide modern technologies such as drones, IoT devices, and automated irrigation systems for teaching and research.
3. Organize regular training programmes for lecturers and students.
4. Improve internet connectivity and electricity supply.
5. Agricultural Science curricula should incorporate more practical applications of smart farming technologies.

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