A Critical Assessment of Drone Technology: Its Prospects and Roles in Sustainable Agriculture and National Food Security in Nigeria

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ABSTRACT

This study was to assess the prospects of drone technology and its roles in sustainable agriculture and national food security in Nigeria. Descriptive survey design was adopted for the study. The study was conducted in Nigeria. The population of the study consisted of all agricultural scientist and home economists in Nigeria. Stratified sampling technique was used in selecting 50 agricultural scientists and 30 home economists which was drawn from each of the geographical zone in Nigeria. This gave a total of 480 sample size used for the study. The instrument used in this study for data collection was a questionnaire titled " Assessment of Drone Technology in Nigeria Questionnaire (ADTNQ)". Face and content validation of the instrument was carried out by an expert in testing, measurement, and evaluation to ensure that the instrument has the accuracy, appropriateness, and completeness for the study under consideration. The reliability coefficient obtained was 0.80, and this was high enough to justify the use of the instrument. The researcher subjected the data generated for this study to appropriate statistical techniques such as percentage analysis. The test for significance was done at 0.05 alpha levels. The drone's most important benefits are that drone mapping provides farmers with very important data such as soil type and texture, climatic conditions, and vegetation study of a large piece of land. A farmer could use a drone to know what the crop yield of the farm is with data acquired from drone mapping. Agriculture plays a major role in the maintenance of national food security in various ways, such as through the production of foods that have attained food availability in the nation. The advancement of agriculture into the production of various kinds of food materials has ensured the food utilization by citizens in the nation. One of the recommendations made was that awareness should be made to farmers concerning the existence and benefits of drones in agriculture. Also there should be a formulation of legislative regulations on the use of the technology.

KEYWORDS: Drone, Drone mapping, Benefits and Limitations

Introduction

Drones are currently leading smart technologies and breaking down barriers in different industries. The innovation that was once primarily used in the military is gradually making its way into a variety of civil industries such as health care, e-commerce, food security, etc. (Agbetiloye, 2022). Drones, also known as unmanned aerial vehicles (UAVs), have not yet made it into the mainstream agriculture space. However, they are playing an increasingly important role in precision farming, helping agriculture professionals lead the way with sustainable farming practices while also protecting and increasing profitability within national food security in Nigeria (Pinguet, 2021). The use of drones in the agriculture industry is steadily growing as part of an effective approach to sustainable agricultural management that allows agronomists, agricultural engineers, and farmers to help streamline their operations, using robust data analytics to gain effective insights into their crops. Crop monitoring, for example, is made easier by using drone data to accurately plan and make ongoing improvements, such as the use of ditches and evolving fertilizer applications. According to Osabohien, Olurinola, Matthew, & Igharo (2021), the agricultural sector has a crucial role in the production of food and the growth of the general economy. It has been argued that growth from the agricultural sector is more efficient in reducing poverty and food insecurity than growth from other sectors of the economy.

Agricultural producers can take reliable decisions to save money and time (e.g., precision farming), get a quick and accurate record of damage, or identify potential problems in the field (Newcombe, 2007). Woodlot assessments, fire surveillance, species identification, volume computation, and silviculture can all be done accurately. In the past, the development of UAV systems and platforms was primarily motivated by military goals and applications. Unmanned inspection, surveillance, reconnaissance, and mapping of inimical areas were the primary military aims (Remondino, Barazzetti, Nex, Scaioni, & Sarazzi, 2011). In recent years, more and more applications of UAVs in the geomatics field have become common. UAV photogrammetry indeed opens various new applications in the close-range aerial domain and introduces a low-cost alternative to classical manned aerial photogrammetry (Eisenbeiss, 2009). The farming industry is facing several severe concerns over increased prices of farm inputs, labor shortages, and climate change at one end; and, at the other end, conventional farming and a lack of farming skills hinder agriculture production from reaching its optimum level. Together, these limitations make agriculture an impracticable and unproductive industry, especially in low-income countries (Adam, 2020). These elements together need the intervention of the most advanced technologies in agriculture, such as digitalizing the aspects of growing crops, automating farm growth factors, and collecting on-farm soil and environmental data to use them in a pre-decisive practice that could help to boost agriculture production. A positive output can be achieved with the induction of COTS drones in the agriculture field that can perform several roles when deployed effectively and can provide a sweet alternative to unskilled or deficient labor, along with saving a lot of money that otherwise goes to waste due to the overutilization of valuable resources and inputs.

Objective of the Study

1. To find out the extent of utilization of drone mapping for agriculture.
2. To examine the roles of drone in agriculture in Nigeria.

3. To assess the impact of drone enhanced agriculture on sustainable food security in Nigeria.

Research Questions

1. What is the extent of utilization of drone mapping for agriculture by farmers in Nigeria?
2. What are the roles of drone in agriculture in Nigeria?
3. What is the impact of drone enhanced agriculture on sustainable food security in Nigeria?

Hypothesis

There is no significant impact of drone enhanced agriculture on sustainable food security in Nigeria.

Conceptual Review

Concept of Agriculture

The English word agriculture derives from the Latin ager (field) and colo (cultivate), signifying, when combined, the Latin agricultura: field or land tillage. But the word has come to subsume a very wide spectrum of activities that are integral to agriculture and have their own descriptive terms, such as cultivation, domestication, horticulture, arboriculture, and vegeculture, as well as forms of livestock management such as mixed crop-livestock farming, pastoralism, and transhumance (Harris & Fuller, 2014). Also, agriculture is frequently qualified by words such as incipient, proto, shifting, extensive, and intensive, the precise meaning of which is not self-evident. Many different attributes are used to define particular forms of agriculture, such as soil type, frequency of cultivation, and principal crops or animals. The term "agriculture" is occasionally restricted to crop cultivation, excluding the raising of domestic animals, although it usually implies both activities. The Oxford English Dictionary (1971) defines agriculture very broadly as "the science and art of cultivating the soil, including the allied pursuits of gathering in the crops and rearing live stock (sic), tillage, husbandry, and farming (in the widest sense)." In this entry, we too use the term in its broadest, inclusive sense.

Concept of Food Security

Food security refers to the measure of an individual's ability to access food that is nutritious and sufficient in quantity. Food security specifies that food must also meet an individual's food preferences and dietary needs for active and healthy lifestyles (Fahy, 2021). Food security is a flexible concept, as reflected by the many attempts to define it in research and policy usage (Peng and Berry, 2019). The concept of food security originated some 50 years ago, at a time of global food crises in the early 1970s. The current widely accepted definition of food security comes from the Food and Agriculture Organization (FAO) annual report on food security, "The State of Food Insecurity in the World 2001": Food security is a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2002). Food security is defined as a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Four dimensions of food security have been identified in line with different levels, which are:

- Availability in the nation
- Accessibility by households
- Utilization by individual
- Stability

It may be considered a time dimension that affects all the levels. All four of these dimensions must be intact for full food security. More recent developments emphasize the importance of sustainability, which may be considered the long-term time (fifth) dimension to food security.

Concept of National Food Security

National food security is said to exist when all citizens and individuals in a nation, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life in the nation. It is a function of three main apparent factors: availability (production and transport), stability, and affordability (access), but the underlying causes of these factors are large in number and are very complex in nature. According to Zainudeen and Dip (2006), ensuring food security is equally important as providing state security and health security, and it is the main underlying factor in keeping mankind healthy and active and, above all, free from hunger, and has been the main concern of every state/nation and the global community.

Concept of Drone

A drone is an unmanned aircraft. Drones are more formally known as unmanned aerial vehicles (UAVs) or unmanned aircraft systems. Essentially, a drone is a flying robot that can be remotely controlled or fly autonomously using software-controlled flight plans in its embedded systems, that work in conjunction with onboard sensors and a global positioning system (GPS) (Lutkevich, 2020). A drone is an aircraft without any human pilot, crew, or passengers on board. UAVs are a component of an unmanned aircraft system (UAS), which includes adding a ground-based controller and a system of communications with the UAV (Hu, Niu, Carrasco, Lennox, & Arvin, 2022). The flight of UAVs may operate under remote control by a human operator, as remotely-piloted aircraft (RPA), or with various degrees of autonomy, such as autopilot assistance, up to fully autonomous aircraft that have no provision for human intervention. According to Näsi, Honkavaara, Hakala, Viljanen, & Peltonen-Sainio, (2017), the central components of the system in remote sensing use are cameras. The other main components are on-board GPS (RasPiGNSS, NV08C-CSM) for collecting UAV position trajectory. Additionally, the Raspberry Pi 2 on-board computer was used for collecting timing data for all devices and logging the GPS. The predominant instrument used in hyperspectral imaging was the FPI (Fabry-Pérot interferometer)-based hyperspectral camera (Oliveira, Tommaselli, & Honkavaara, 2016). This technology provides spectral data cubes (spectral range 500-900 nm) in frame format and enables stereoscopic measurements when overlapping images are used. The field of view (FOV) is 18° in the flight direction, 27° in the cross-flight direction, and 31° in the format corner. This technology has already shown potential for various environmental mapping applications, such as forestry, peat production, and precision agriculture (Kaivosoja, Pesonen, Kleemola, Pölönen, Salo, Honkavaara, Saari, Mäkynen, & Rajala, 2013). An off-the-shelf RGB camera (Samsung

NX500) was also used for capturing high spatial resolution stereoscopic images that can be used for stereoscopic 3D measurements to provide the 3D geometrical structure of the object.

Concept of Drone Mapping

Drone mapping is an aerial survey conducted by a drone and specialist cameras, which can include RGB (for photogrammetry), multispectral, thermal or LiDAR sensors. This method enables the collection of highly accurate data extremely quickly. This method enables the collection of highly accurate data extremely quickly. In fact, one piece of analysis showed that drone mapping collects data in excess of 90% faster than manual methods. It is also a safer way of gathering data: no longer do you need to have staff walking over dangerous terrain or working at heights—the drone can do it for you. This data can be processed through drone mapping software to create a range of assets, such as 3D models, 2D maps, and digital elevation models, which can be used to extract valuable information like highly-accurate measurements and volumetric calculations. This information helps with informed decision-making, provides valuable insights, including identifying mistakes or problems, keeping up-to-date with the progress of a project, and streamlines effective communication with colleagues, stakeholders, and the community.

Simply, a UAV is flown over a location and uses high-resolution photography to capture high-resolution details of the site. Different systems can be used, though most commonly, photogrammetry and LiDAR can get exact measurements and details of the location. LiDAR has been around for many years and uses light in the same way as radio waves are used in RADAR, timing the speed of photons reflected from a point instead of radio waves to achieve an accurate image. The hardware is still very expensive compared to photogrammetry, which requires much simpler and cheaper equipment. Photogrammetry involves taking thousands of 2D images with a high resolution camera – not unlike that used in a DSLR camera. The images are then 'stitched together' using Simultaneous Localization and Mapping (SLAM) software to achieve a highly accurate, measurable image of the site. Thanks to cost advantages, photogrammetry is much more competitive than LiDAR in most applications. Simultaneous Localization and Mapping (SLAM) such as that provided by diorama triangulates set points of a 3D location by monitoring those points over successive camera frames. In doing so, the computer system can measure exact distances between points in the images.

Roles and Benefits of Drone and Drone Mapping in Agriculture

Drones allow farmers to constantly monitor crop and livestock conditions by air to quickly find problems that would not become apparent in ground-level spot checks. For example, a farmer might find through time-lapse drone photography that part of his or her crop is not being properly irrigated. Agricultural drone technology has been improving in the last few years, and the benefits of drones in agriculture are becoming more apparent to farmers. Drone applications in agriculture range from mapping and surveying to crop dusting and spraying. On the surface, agricultural drones are no different than other types of drones. The application of the UAV simply changes to fit the needs of the farmer. There are, however, several drones specifically made for agricultural use (more on that in a later section). According to Näsi et al. (2017), drones have revolutionized agriculture by offering farmers major cost savings, enhanced efficiency, and more profitability. By quickly surveying vast stretches of farmland, drones can map the property, report on crop health, improve spraying accuracy, monitor livestock and irrigation systems, and more. The ability to collect and analyze this data in real time has tangible outcomes for farmers, such as better crop yields, fewer resources expended on weeds and herbicides, and overall improved management decisions. Drone-based mapping enables us to map agricultural lands with a very high spatial resolution, which enables us to monitor even small anomalies in vegetation inside the parcel. Drought-induced uneven germination and growth, seedling loss due to flooding and anoxia, disease outbreak, pest invasion, unbalanced nutrient availability and uptake, and overwintering damage can all contribute to uneven plant stand growth. In addition, by monitoring the variation of vegetation inside a parcel, a drone can facilitate monitoring of differences between field parcels in their production capacities at farm-scale.

Drones may also provide additional high-resolution data that can be used to interpret satellite data when assessing variation in productivity or determining yield gaps (the difference between potential and attained yields) of fields on a landscape to national scale (Näsi et al., 2017). By utilizing hyperspectral imagery, soil data is collected by UAVs before the planting of any crop, which gives farmers the existing position of the soil fertility, soil moisture, air and surface temperature, organic matter content, and water holding capacity of the soil. Crops get fertilization based on the data already collected from the field. The standing crop data also helps in monitoring the response of fertilization and other crop additives. According to Scull (2003), the data collected from the soil and farm helps farmers to choose the best-suited planting patterns, planting schedule, quantities of seed, and manage the organic content of the soil. Moreover, the farmers become well informed about the necessary repairs and amendments that lead to getting a better yield than the farmers growing their crops conventionally in their vicinity. Climate change and extreme weather events throughout the world are potential threats to agriculture. The need arises to utilize water resources effectively and wisely. UAVs can help farmers monitor and control irrigation schedules, especially while growing multiple crops on the same agricultural farm. Sensors get installed on the drippers and irrigation system, whereas any soil moisture variation is sensed by the ground sensors that allow the drippers to stop or start working. Another way is to link the entire irrigation system with the ground controller, and a single UAV flight can switch them on or off. Additionally, a UAV allows farmers to monitor irrigation practices remotely. Drones equipped with hyperspectral thermal cameras give you the exact amount of water needed for any field or the parts of the crop field that appear dry and need water. This monitoring supports effective management to save a lot of water that can be used for growing extra crops on any farm (Albornoz, 2017).

The UAVs' spraying capability is used for aerial spraying of insecticides, fertilizers, herbicides, and micro-fertilizers on the standing crops efficiently whenever required. Moreover, spot spraying is also possible if some disease or pests prevail on a small number of plants or some parts of the plants (Homeland Surveillance and Electronics, 2016). UAVs can provide an immediate solution by spraying only the infested parts of such plants. Pre-emergence and post-emergence herbicide applications are also possible since UAVs can spray herbicide evenly near the surface. Similarly, liquid foliar fertilizer and micro-fertilizer practices provide similar precision as herbicides and allow for spot spraying due to the precision drone's height management capability. Other advantages of aerial spraying include low volume spraying to avoid reaching the toxins to the soil surface to pollute it. These precise applications save input costs and time that are otherwise wasted in deploying labor and putting in extra cropping inputs conventionally (Garre, 2018). The seeding for the small and medium-sized products is equally beneficial for saving time and planting what is needed in the shortest possible planting periods. Usually, the majority of growers get a limited period between the harvesting of the standing crop and planting a new crop on the same piece of land, since such soils need a lot of cultural practices in this period. UAVs solve both selective and bulk seed casting in small and medium-sized production by maintaining the desired planting distance with accuracy and efficiency in the shortest possible time. Moreover, the UAVs are also capable of bulk tree seed casting in the forestation projects where human access is denied. They can also be a potential tool for broadcasting seeds of annual or perennial grasses in the pastures or rangeland (Andrio, 2019).

The UAVs have built-in equipment for carrying out crop mapping and surveying on the types of terrain and changing weather conditions both for agriculture and livestock. The UAVs' bird-eye images help the farmers to mark the outer boundaries of their cropped farms, besides monitoring the farm activities. UAVs' real-time footage can provide details of the infrastructure, including differences between crops, ponds, roads, and machinery at the farm. Moreover, they can provide the details of the covered areas with their measurements. Another positive aspect of UAV surveying and crop mapping is that it quickly reflects the changes in infrastructure and cropping patterns. Weed detection is also possible using an autonomous flight within the cropped areas (Bah, Hafiane, & Canals, 2017). This UAV feature allows the farmers to monitor real-time farm activities across the field while also watching livestock in the grazing lands. UAVs' thermal imagery can detect every sort of movement on the farm and can help farmers monitor and control entire activities automatically. Early pest and disease detection is possible while monitoring crops using a UAV. Furthermore, it can assist growers in monitoring and diverting livestock movement if they have a basic understanding of how to fly agriculture drones for such purposes. According to Montero & Rueda (2018), UAVs' real-time monitoring can also be used for watching the working and performance of farm machinery with a single flight, such as tractors, threshers, and harvesting efficiency of farm machinery, whereas the additional automation can help the growers monitor the working of irrigation systems and drippers' performance. Installation of field sensors can allow the growers to check soil moisture content, pH values, and surrounding temperature, which leads to the complete automation of the entire farm practices.

Impact of Agriculture on National Food Security

According to Pawlak & Kołodziejczak (2020), the agricultural sector plays a strategic role in improving the availability of food and achieving food security. Keeping in mind that agriculture has a much greater impact on reducing poverty and improving food security than the other sectors of the economy and considering differences in the potential for agricultural production, agricultural development is critically important to improving food security and nutrition. Its impact includes: increasing the quantity and diversity of food; driving economic transformation; and providing the primary source of income for many of the world's poorest people. Numerous empirical studies across many countries over many years show that both agricultural development and economy-wide growth are needed to improve food security and nutrition, and that the former can reinforce the latter. The livestock sector is a powerful engine for the development of agriculture and food systems. It drives major economic, social, and environmental changes in food systems worldwide and provides an entry point for understanding the issues around sustainable agricultural development as a whole, given the importance and complexity of its roles and contribution to food security and nutrition (HLPE. 2016).

Agricultural development is key to food security in several ways, contributing to food availability, access, and stability and, through the diversity of foods produced, food utilization. It has accompanied population growth, resulting in a threefold increase in global agricultural production in 50 years, with only a 12% increase in farmland area (FAO, 2014a), owing primarily to the "Green Revolution," though with significant variations across countries and regions. The Green Revolution built on the work of crop scientists and, targeting specific crops, involved the use of high-yielding varieties, expanded irrigation, the application of synthetic fertilizers and pesticides, as well as improved management techniques. But the specialization of agricultural systems has resulted in significant levels of biodiversity loss, with potential effects on the environmental sustainability of farming systems and on the possibility of a diverse food supply in the future.

According to HLPE (2016), the WDR report showed how, in the "agriculture-based" countries particularly, agriculture and associated industries are essential to reduce mass poverty and food insecurity and will require a productivity revolution in smallholder farming, a sector that in these countries tends to be dominated by women. In "transforming" countries, the WDR suggests extreme rural poverty must be addressed by providing multiple pathways out of poverty, including through a shift to higher-value agriculture, more rural-based non-farm economic activity, and assistance to people transitioning out of agriculture. In "urbanized" countries too, agriculture can help reduce the remaining rural poverty if smallholders can be connected to modern food market chains and if jobs can be created in agriculture and agro-industry, along with the creation and application of markets for environmental services. The WDR proposes a revitalization of the agriculture sector by tackling underinvestment and mis-investment in agriculture, reducing poverty, ensuring economic growth, improving livelihoods, and strengthening food security across the developing world.

Limitations or challenges of drone mapping in farming

High altitude surveying can have an impact on gasoline and turbine engines, while payload constraints force the use of low weight IMU, preventing direct geo-referencing solutions. A drawback might also be the necessary presence of at least two people for system maneuvers and transportation (Remondino, Barazzetti, Nex, Scaioni, & Sarazzi, 2011). The acquisition of image blocks with suitable geometry for the photogrammetric process is still a critical task, especially in the case of large scale projects and non-flat objects (e.g. buildings, towers, rock faces, etc.). While the flight planning is quite simple when using nadiral images, the same task becomes much more complex in the case of 3D objects requiring convergent images and, maybe, vertical strips. Future work has to be done to develop tools for simplifying this task. According to Laszlop (2020), one of the prime limitations for small growers is interpreting the data collected by the UAVs. Technical advances such as software development and vehicle specifications are so rapid in the precision agriculture industry that the growers can't catch them within their timeframe. Some lighter UAVs are unstable in the wind and sometimes collect weak imagery that is not worth processing for the benefit of the UAV operators. It is more important to know that effective calibration needs specialized software, time, and knowledge to acquire data from variable altitudes and angles and may not be supported by some other software for processing and taking into account for acquisition. Moreover, a high initial investment is required for purchasing agriculture UAVs, while their flight endurance is limited to half an hour to one hour, other than hybrid vehicles that can keep flying for two hours (Laszlop, 2020).

According to Equinox's Drones (2020), one substantial downside to drone technology's growth is its vulnerability. Hackers can quickly attack a drone's central control system and become the drone's original controller. The primary control system includes significant knowledge that is crucial for hackers to evade without the initial operator's awareness. Hackers can acquire private information, corrupt or damage the files, and leak data to unauthorized third parties. Drones are more vulnerable to weather conditions when compared to traditional aircraft. For example, if the climatic conditions are unfavorable, the UAV will not maneuver appropriately or gather reliable data or imagery (Equinox's Drones 2020). However, there are drones available that are more stable and can withstand gusts of wind successfully. If one necessitates seizing accurate, high-quality data, they need to possess the required skillset. This specification would indicate that an average farmer would require comprehensive training or a third-party drone service provider to capture, process, and analyze farming data. With expanding operators in the industry, drone costs and their accompanying resource expenses will gradually decrease. Furthermore, (Equinox's Drones 2020) stated that one of the limitations to expanding drone technology in precision agriculture is its data transmission speed, which some suppose could be a week. If the time necessitated for data delivery results in a farmer's unproductivity and damage to fertilizers, crops, or pesticides, the operation of the drone would be a waste in the end. Thus, if data transfer speed is slow, suffering and damage can occur in that period, following all efforts going to waste.

Methodology

Descriptive survey design was adopted for the study. The study was conducted in Nigeria. The population of the study consisted of all agricultural scientist and home economists in Nigeria. Stratified sampling technique was used in selecting 50 agricultural scientists and 30 home economists which was drawn from each of the geographical zone in Nigeria. This gave a total of 480 sample size used for the study. The instrument used in this study for data collection was a questionnaire titled " Assessment of Drone Technology in Nigeria Questionnaire (ADTNQ)". Face and content validation of the instrument was carried out by an expert in testing, measurement, and evaluation to ensure that the instrument has the accuracy, appropriateness, and completeness for the study under consideration. The reliability coefficient obtained was 0.80, and this was high enough to justify the use of the instrument. The researcher subjected the data generated for this study to appropriate statistical techniques such as percentage analysis. The test for significance was done at 0.05 alpha levels.

Result and Discussion

Research Questions 1: The research question sought to find out the extent of utilization of drone mapping for agriculture by farmers in Nigeria. To answer the research question percentage analysis was performed on the data, (see table 1).

Table 1: Percentage analysis of the extent of utilization of drone mapping for agriculture by farmers in Nigeria

EXTENTS	FREQUENCY	PERCENTAGE
LOW EXTENT	317	66.04**
VERY LOW EXTENT	163	33.96*
TOTAL	**480**	**100%**

** The highest percentage frequency

* The least percentage frequency

SOURCE: Field survey

The above table 1 presents the percentage analysis of the extent of utilization of drone mapping for agriculture by farmers in Nigeria. From the result of the data analysis, it was observed that the highest percentage (66.04%) of the respondents affirmed that the extent of utilization of drone mapping for agriculture by farmers in Nigeria is low, while the least percentage (33.96%) of the respondents stated that the extent of utilization of drone mapping for agriculture by farmers in Nigeria is very low.

Research Questions 2: The research question sought to find out the roles of drone in agriculture in Nigeria. To answer the research percentage analysis was performed on the data, (see table 2).

Table 2: Percentage analysis of the roles of drone in agriculture in Nigeria

ROLES	FREQUENCY	PERCENTAGE
Drones allow farmers to constantly monitor crop and livestock conditions by air	99	20.62**
Drones have offered farmers major cost savings, enhanced efficiency, and more profitability	92	19.17*
Drones can map the property, report on crop health, improve spraying accuracy	96	20
Drones have the ability to collect and analyze this data in real time and this has tangible outcomes for farmers	98	20.42
Provision of adequate data that help get Crops accurately fertilized in the farm	95	19.79
TOTAL	**480**	**100%**

** The highest percentage frequency

* The least percentage frequency

SOURCE: Field survey

The above table 2 presents the percentage analysis of the roles of drone in agriculture in Nigeria. From the result of the data analysis, it was observed that the role “Drones allow farmers to constantly monitor crop and livestock conditions by air” 99(20.62%) was rated the highest, while the role “Drones have offer farmers major cost savings, enhanced efficiency, and more profitability” 92(19.17%) was rated the least percentage.

Research Questions 3: The research question sought to find out the impact of drone enhanced agriculture on sustainable food security in Nigeria. To answer the research percentage analysis was performed on the data, (see table 3).

Table 3: Descriptive statistics of the impact of drone enhanced agriculture on sustainable food security in Nigeria

Variable	N	Arithmetic mean	Expected mean	R	Remarks
Food Security	480	11.80	12.5	0.92	*Strong to Perfect Relationship
Droned Agriculture		13.47	12.5		

Source: Field Survey

The above table 3 presents the result of the descriptive analysis of the impact of drone enhanced agriculture on sustainable food security in Nigeria. The two variables were observed to have strong to perfect relationship at 0.92%. The arithmetic mean for food security (11.80) was observed to be less than the expected mean score of 12.5. In addition to that, the arithmetic mean as regards droned agriculture (13.47) was observed to be higher than the expected mean score of 12.5. The result therefore means that there is remarkable impact of drone enhanced agriculture on sustainable food security in Nigeria, even though the food security level is low in Nigeria with the hope of much more improvement as more drone technology is constantly adopted.

Hypotheses

Hypothesis One: The null hypothesis states that there is no significant impact of drone enhanced agriculture on sustainable food security in Nigeria. In order to answer the hypothesis, simple regression analysis was performed on the data (see table 4)

Table 4: Simple Regression Analysis of the impact of drone enhanced agriculture on sustainable food security in Nigeria

Model	R	R-Square	Adjusted R Square	Std. error of the Estimate	R Square Change
1	0.92a	0.85	0.85	0.58	0.85

***Significant at 0.05 level; df= 478; N= 480; critical R-value = 0.098**

The above table 4 shows that the calculated R-value (0.92) was greater than the critical R-value of 0.098 at 0.5 alpha levels with 478 degrees of freedom. The R-Square value of 0.85 predicts 85% of the impact of drone enhanced agriculture on sustainable food security in Nigeria. This rate of percentage is highly positive and therefore means that there is significant impact of drone enhanced agriculture on sustainable food security in Nigeria. It was also deemed necessary to find out the impact of the variance of each class of independent variable as responded by each respondent (see table 5).

Table 5: Analysis of variance of the impact of drone enhanced agriculture on sustainable food security in Nigeria

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	937.12	1	937.125	2736.81	.000b
Residual	163.67	478	0.34		
Total	1100.80	480			

a. Dependent Variable: Food Security
b. Predictors: (Constant), Droned Agriculture

The calculated F-value (2736.81) and the P-value as (.000b). Being that the P-value (.000b) is below the probability level of 0.05, the result therefore means that there is significant impact exerted by the independent variables i.e. droned agriculture on the dependent variable which is food security. The result therefore means that there is significant impact of drone enhanced agriculture on sustainable food security in Nigeria. The result therefore is in agreement with the research findings of Pawlak & Kołodziejczak (2020) who noted that the agricultural sector plays a strategic role in improving the availability of food and achieving food security. Bearing in mind that droned agriculture has a much greater impact on reducing poverty and improving food security than the other sectors of the economy, and considering differences in the potential for agricultural production. The significance of the result caused the null hypotheses to be rejected while the alternative was accepted.

Conclusion

Technology has been of great advantage in several ways in different sectors of the world. The world is advancing into a technological era and these technologies have now been seen to be of great benefit in farming processes, guiding precise farming. Agriculture will produce better results with the help of drones, as farming activities such as fertilizer spraying, irrigation, and even security functions based on their payloads will be much easier. The drone's most important benefits are that drone mapping provides farmers with very important data such as soil type and texture, climatic conditions, and vegetation study of a large piece of land. A farmer could use a drone to know what the crop yield of the farm is with data acquired from drone mapping. It is also concluded from the study that food security in a nation, otherwise known as national food security, is essential for the growth and existence of a nation. Agriculture plays a major role in the maintenance of national food security in various ways, such as through the production of foods that have attained food availability in the nation. The advancement of agriculture into the production of various kinds of food materials has ensured the food utilization by citizens in the nation.

Recommendations

From the study the following recommendations are suggested

1. Awareness should be made to farmers concerning the existence and benefits of drones in agriculture. Also there should be a formulation of legislative regulations on the use of the technology.
2. Farmers should be trained on the use of drone technology for agricultural purposes.
3. The drone should be used in clear weather when carrying out drone mapping to ascertain accurate data.

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