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Integrated application of drones for soil management and precision agriculture in Nigeria

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Abstract

The recent push for precision agriculture has resulted in the deployment of highly sophisticated Information and Communication Technology (ICT) gadgets in various agricultural practices and methods. The introduction of ICT devices has been linked to significant improvements in agricultural activities. These devices have been shown to enhance the optimal management of critical resources such as water, soil, crop and arable land. Again, ICT devices are increasingly attractive due to their flexibility, ease of operation, compactness and superior computational capabilities. Especially when in comparison to the mundane methods previously used by most small- and large-scale farmers. For instance, ICT devices such as Unmanned Aerial Vehicles (UAVs) also referred to as drones, are increasingly being deployed for remote sensing missions where they capture high quality spatial resolution images. The data generated by these UAVs provide much needed information that aids in early spotting of soil degradation, crop conditions, severity of weed infestation and overall monitoring of crop yield variability. This enables farmers to acquire on-the-spot information that will enhance decision making within a short period of time, which will in turn contribute to reduction in running cost and potentially increase yield. It is safe to say that full potentials of drones are yet to be fully utilized in the Nigerian agricultural sector. This is due to several factors; most notably are the numerous challenges that accompany the introduction and adoption of much new technologies. Other factors; include high cost of technology, inadequate or total lack of skilled labour, poor awareness and low-farmer literacy. Therefore, this review work highlights the global progress recorded as a result of the recent application of drones for soil management and efficient crop production. Furthermore, key discussions surrounding the application of drones for precision agriculture and the possible drawbacks facing the deployment of such technology in Nigeria has been covered in this work.

Keywords: Drones; Gadget; Devices; Precision; Agriculture; ICT; remote sensing; Soil Management; Technology

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1.0. Introduction

1.1 Background of the study

Climate change has a major impact on food security. More than 815 million people suffer from chronic hunger and 64% of people who suffer from chronic hunger are in Asia (FAO, ITU 2018). The world is expected to increase food production by almost 50% by 2050 to feed a population of 9 billion, but resources such as land and water are increasingly scarce. Agricultural sector is the most promising sector and challenging sector because it depends on climate or weather conditions of the soil, irrigation water quality and quantity and their application rate. Agricultural communities and other agricultural actors need to adapt to the effect of climate change and other challenges in agriculture. In this context, ICT based tools and technologies for decision making with accurate, reliable and timely information plays an important role. Agriculture must turn to emerging technologies to find solutions that will aid in overcoming some of the challenges hindering sustainable soil management for maximum food production.

One of the most recent developments is the increase in usage of small unmanned aerial vehicles (UAVs), commonly known as Drones, for agriculture. Drones are planes with remote control with no human pilot on board. These drones have enormous potential for support in agriculture with evidence-based planning and spatial data collection. Despite some inherent limitations, these tools and technologies can provide valuable data that can be used to influence policies and decisions. Drones are used in various fields, from the army, humanitarian aid, Disaster Agricultural Management. A recent PwC report (PwC, 2016) estimates the agricultural drone market is worth US $ 32.4 billion. The advantages that an "eye on sky" provides when combined with analytical tools that can interpret data and images to actionable information marked the beginning of a new revolution. The United Nations has tested drones in different areas of its mandate, from

humanitarian crises to agriculture. For example, the World Food Program (WFP) has joined the Belgian government to distribute drones in humanitarian emergency situations (WFP, 2017) the usefulness of drones to facilitate the rapid collection of data with greater precision and a safer emergency surveillance system was a key element to demonstrate this on the field during the difficult humanitarian crises.

The agricultural industry in Nigeria faces many problems, ranging from terrible infrastructure to illiteracy. Fortunately, new technology companies have already started working on improving the difficulties of local farmers. Technology companies such as Beat Drone which was founded in 2016 by Odionye Confidence, Chidinma Nwokonko and Yinka Ojomo, farmers can request a drone, schedule a date for drone deployment and make their payment, then the drones are sent to their farms for the specified activities. The company had signed a deal with the Rice Farmers Association of Nigeria to access and deploy drones to 1.5 million hectares of rice farming lands within the next 12 months. Beat Drone aims to be in 30 African countries within the next five years. (Olanrewaju, 2018). The use of drones in agriculture is extending at a brisk pace in crop production, early warning systems, disaster risk reduction, forestry, fisheries, as well as in wildlife conservation, for example. Crop production: precision farming combines sensor data and imaging with real-time data analytics to improve farm productivity through mapping spatial variability in the field. Data collected through drone provide the much-needed wealth of raw data to activate analytical models for agriculture. In supporting precision farming, drones can do soil health scans, monitor crop health, assist in planning irrigation schedules, apply fertilizers, estimate yield data and provide valuable data for weather analysis. Data collected through drones combined with other data sources and analytic solutions provide actionable information.

As the human population in Nigeria continues to grow, farmers need to produce abundant food, increasing agricultural productivity is essential to achieve the objectives of food security and economic development in the face of rapid population growth. The agricultural sector currently supports more than 80% of Nigerians. Agricultural GDP in Nigeria increased to 5,288,339.21 million NGN in the third quarter of 2018 compared to 3,789,720.12 million NGN in the second quarter of 2018 and is expected to evolve around 5,834,951.00 million NGN in 2020, according to econometric models (Dotun, 2019). That said, there are many possibilities in Nigeria's agricultural sector and if properly financed, achieving food security by protecting crops from rapidly growing populations will not be an unrealistic dream.

1.2 Objectives of study

This review paper analyses and highlights global progress recorded as a result of the recent application of drones for sustainable agriculture, soil management and efficient crop production. Furthermore, key discussions surrounding the application of drones for precision agriculture and the possible drawbacks facing the deployment of such technology in Nigeria. This research work would also provide a careful analysis of drone technology benefits and limitations in agriculture and would also suggest future enhancement.

1.3 Significance of the study

i. This review paper is aimed at enlightening famers, stakeholders and policy makers, about drone technology.

ii. The findings of this study will be of immense benefits for precision agriculture by giving both farmers and agricultural stakeholders in Nigeria the ability to tap into available academic materials which may not be readily available within.

iii. The finding of the study will be much useful to agricultural stakeholders and farmers seeking to improve their current farm technology to a more efficient one, through the implementation of drone technology.

iv. The finding will afford them the opportunity to know the issue involved and benefits of drone technology.

2.0. **Materials and methods**

This review was conducted at the Nigeria Institute of Soil Science Utako, Abuja and the Department of Chemistry, Faculty of science, Nelson Mandela University, Port Elizabeth, South Africa. It is based on review of various related works on how drones are currently revolutionizing the agricultural sector around the world. For this study, secondary data was employed, which is documentary review. These data were sourced from various related publications, research works and journals.

2.1 How Drone Technology Work

To gain a better understanding of drones use in agriculture, let's take a closer look at drone technology. Typically, a drone construction includes propulsion and navigation systems, GPS, sensors and cameras, programmable controllers as well as equipment for automated flights.

The technology used for UAV drones for agriculture are built in a way that enables them to capture more accurate information than airplanes and satellites are capable of collecting. Drone-based agricultural technology software processes the collected data and delivers it in an easy-to-read format.

All in all, the data collection process in the case of agriculture drones includes four logical steps:

1. Set flight parameters: Outlining and evaluating the surveillance area and uploading GPS info into the drone navigation system.

2. Autonomous flights: A UAV drone carries out a flight pattern according to the pre-established parameters and collects the required data.

3. Data upload: The drone submits the data it has captured for processing and analysis.

4. Information output: After the data has been processed, it is sent to farmers in a readable format. The report contains insightful information which accounts for better farm management decisions.

2.2 Areas of Drone Application In The Nigerian Agricultural Sector

The versatility of drones offers many ways to improve existing agricultural methods and processes, including one of the major factors to meeting the ever growing demand for food and improving the current levels of water usage in Nigeria, is the introduction of new Agricultural technology and Artificial Intelligence. These new technologies are beginning to enhance or improve new and existing methods and tools and have already been implemented on farm connected tractor, which is a well-known example of new technologies already in use. However, drones are a newer and less mature tool in terms of new technologies that are driving the development of precision agriculture in Nigeria and the world at large.

Currently, most agricultural drones are medium sized (mostly for analytical applications), while larger drones are used when it is necessary to transport a load (i.e. seed planting or spray applications). Most indust6ries that currently use drones prefer to use multi-rotor setups in agriculture, likely due to their lower cost and high level of simplicity. This review presents six ways that drones can be at the centre of agricultural productivity and sustainability in Nigeria.

2.2.1 Soil and field analysis

Drones can play a crucial role in the early stage of plant cycle. They can be used to create accurate three-dimensional maps for early soil analysis, which are useful when planning patterns for seed planting. After planting, soil analysis with a drone provides data for irrigation and nitrogen level management. This information can also enable farmers to determine the most effective standards for planting, crop and management, soil, and more. Continuous monitoring can help in improving better usage of water resources and control the nutrient content of plants more efficiently.

Source: MIT Technology Review

2.2.2 Aerial planting

The system of using drone for planting are currently being developed with the aim of reducing the cost of labours by firing seed pods directly to the ground using compressed air. This avoids the hug cost of labour traditionally associated with planting activities. Crop planting using drones is relatively a new technology and is not used as often. However, some companies are experimenting with planting drones. Essentially, manufacturers are experimenting with custom systems that can be used to shoot seed pods in prepared soil.

New drone companies have played a key role in developing unique drone technologies to address a variety of agricultural and environmental problems. Drone Seed is an example of companies that uses drones that are capable of delivering up to 57 pounds of payload in the form of tree seeds, herbicides, fertilizers, and help out in reforestation projects and replanting projects. The drone technology minimizes the need for field planting, which can be costly, time consuming, and tiring. The same drone technology can be adapted and applied to a variety of farm types, thus reducing total planting time and labour costs.

2.2.3 Crop spraying

The capability of drones to easily change their flight altitude and routes to the surrounding topography and geography is based on the use of increasingly sophisticated equipment such as RaderLIDAR, which makes drones well suited for crop spraying, since they can scan the ground and apply the spray in time with great precision. Some experts maintain that spraying with drones can be up to five times faster than regular machines. Plants need to be fertilized and sprayed evenly for high yields. Traditionally, this was done manually, by vehicle or even by plane. These methods are not only ineffective and difficult, but can also be very expensive.

With the approval of the Nigerian Civil Aviation Authority (NCAA), drones can be equipped with large tanks that can be filled with fertilizers, herbicides or pesticides. Using drones to spray plants is much safer and cheaper. Drones can even be operated completely autonomously and programmed for specific schedules and routes. For example, if a fungal breakout occurs in a particular section of the crop, drones can be used to spot and treat the issue.. With the speed at which drones operate, you can diagnose and treat potential plant problems before they become a widespread problem around the whole farm. Traditional methods of spraying crops were incredibly difficult. If you had a problem with weeds or a specific crop, the entire area would have to be sprayed. It is a great waste of time and resources because someone has to cover the entire farm area, in addition to the general cost of pesticides and the environmental implications of using chemicals. Drone spot spraying can do the same job in less time, with less financial resources and lower environmental implications.

Source: 2018 Outstanding Drone (website)

2.2.4 Crop monitoring

Satellite imagery was previously the most advanced form of crop monitoring, but suffers from some major drawbacks:

• Satellite imagery is very costly.

• Images must be ordered in advance and can be imprecise.

• Poor weather impedes data quality.

Drones however can monitor crops much more accurately, frequently and affordably, delivering higher quality data that is updated regularly to provide insight into crop development and highlight inefficient or ineffective practices According to Sense Fly (a drone manufacturer specializing in agriculture) the use of drones by the Ocealia group has led to an 10% average increase in crop yields health assessment.

Drones can also be used to generate images of multispectral (based on the amount of reflected green and infrared light), which are then analyzed to track changes in health and maturity of crops. The ability to quickly and accurately assess the health status of a crop can be invaluable to farmers, if for example a bacterial or fungal infection is found, early detection can enable the farmer to quickly take measures to correct or control the problem.

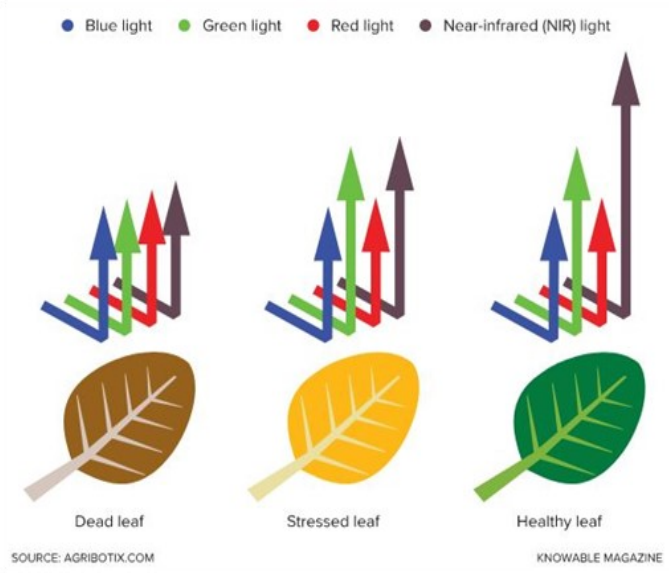
2.2.5 Irrigation

Agriculture is responsible for the vast majority of the 70% of water usage worldwide, more than double that of industry. Excessive water usage is not only wasteful, but also increasingly intolerable as competition for the planet's limited resources increases in the face of rapid population growth. Two of the factors that contribute to the excessive usage of agricultural water are Leaky irrigation systems and wasteful field application techniques, which can both be managed using drones.

Drones equipped with special monitoring devices can be used to identify the parts of a field that suffer from “hydric stress” “stress” (inadequate of water of sufficient quality). They use infrared and heat sensors to take snapshots of the entire fields that allow targeted diagnosis of areas receiving too much or too little water. These drones also allow for the vegetation index (density and health of the crop) to be calculated while the crop is growing, enabling and informing better crop management

2.2.6 Health assessment

It is important to assess crop health and identify bacterial or fungal infections on trees. By scanning a crop with near infrared and visible light, drones can identify plants that reflect different amounts of green light and NIR light.



Early efforts by NASA to monitor vegetation growing in the Great Plains via satellite led to the development of the normalized difference vegetation index (NDVI). This visual yardstick of plant greenery is possible because plant leaves absorb and reflect different wavelengths of light: chlorophyll in healthy leaves absorb visible light (some green is reflected, which we see) while reflecting near-infrared light. A yellow, stressed leaf and a dead leaf (as well rocks as soil) reflect and absorb these wavelengths differently. Drones equipped with sensors can gather thesespectral data and create maps that show variability in crop health. Moderns tweaks — sensors for additional wavelengths of light or using filters or lasers, for example — and more sophisticated analyses offer an improved resolution for farmers who want a quick evaluation of a field

Drones can be use to scan, take inventory and examine slow-growing plants that may require a dose of nitrogen or another remedy. Sensors that measure certain wavelengths of light absorbed and reflected by plants can produce colour contrast images that highlight problem areas in a field. The images generated from this data contain NDVI (Standard Difference Vegetation Index) maps that were created long ago with satellites and planes and calculate the ratio of the difference between infrared and visible light radiation. This information can generate 3-D images that track changes in plants and indicate their health status. Quick response can save an entire farmland. Once a disease is discovered, farmers can use drones to monitor and apply treatment, more efficiently. Both options increase a plant's ability to overcome disease. And in the event of a poor harvest, the farmer can more effectively document losses on insurance claims. On-site monitoring takes time and manpower.

2.3 Why Drone in Agriculture?

Agriculture is a significant sector in the Nigeria economy as it is the backbone of its economy. However, majority of the farmers in the country do not benefit as much as it would be expected of them. It has been observed over the years that even with great increase in the use of ICT gadgets such as drones in various countries in Africa, it has still witnessed different problem of poverty, cost, adoption and access to latest technology, power supply, poor infrastructure, literacy and manpower, Omotayo (2005).

So, what can drones do for agriculture? The answer to this question boils down to increasing overall efficiency, but there's more to drones than just that. As drones become an integral part of smart (or 'precision') farming, they help farmers deal with a wide range of challenges and reap a great number of benefits.

Most of these benefits stem from eliminating any guesswork and reducing uncertainty. The success of farming normally depends on a plethora of factors farmers have little or no control over: weather and soil conditions, temperature, precipitation, etc. The key to efficiency lies in their ability to adjust, which is impacted by a large extent by the availability of accurate nearly real-time info. Here's where the use of drone technology can truly become a game changer. By gaining access to a vast pool of data, farmers can increase crop yields, save time, reduce expenses and act with unparalleled accuracy and precision.

The world as we know it today is fast paced: changes, alterations, and transformations happen in almost a blink of an eye. Adaptation is critical, and given the growing population and the global change of weather conditions, farmers will be required to utilize new-generation technologies to address emerging challenges.

With the aid of UAVs, farmers can now benefit through the following;

2.4 Benefits of Drones in Agriculture

- Increased Yields - Find potentially yield limiting problems in a timely fashion, early detection of crop diseases for example allows farmers to take an early intervention thereby securing their yield.
- Time and Cost Savings - Drones collect data easily and reduce manpower needed
- Return on Investment - according to (FAO Blog post 2017), " drones identify issues, and resolve them quickly, increasing yields"
- Ease of use - The drone can be very complex to set-up and operate but they are relatively easy to control and drive
- Integrated GIS Mapping - drones generate data that can be georeferenced and aids in GIS for drawing field borders for flight pattern
- Crop Health Imaging - due to high resolution images and infra Red and related technologies, drones are able to detect the crop related diseases.
- Failsafe - The Drone Flies Home: As an added safety net with the flip of switch your Precision Drone will return to its original take off location.

2.5 Factors That Hinder the Implementation Of Agricultural Drones Technology In Nigeria

While the potential for drone use in agriculture is significant, there are still several notable impediments to their progression in Nigeria beyond the niche market they occupy today. UAV deployment has its own challenges which may be classified under four broad categories: technological, economic, social and legal and regulatory as suggested by Clothier et al. (2015). In some cases government agencies and private sector operators are already working on solutions which are described below.

Challenges in implementing the UAV's in Nigeria agricultural sector include the following are classified into four categories this review:

1. Economic: The financial situation of most famers in Nigeria is likely to hamper adoption

2. Technological: Quality of data captured

3. Social: Ability of farmers to Access and Adapt to the drone technology

4. Legal and regulatory

2.5.1 The financial situation of most famers in Nigeria is likely to hamper adoption

Agriculture remains a difficult, low margin business for many farmers, with governments frequently assisting when adverse weather or market conditions arise Despite their savings potential, drones still require substantial capital investment and technical expertise to be acquired and properly utilised, making them difficult to justify for many small to medium sized farms that are less likely to benefit from economies of scale. According to the MSA (the farmers' social security in France), around 30 of farmers reported income below 350 per month in 2016.

Currently, drones used in agriculture are generally either bought and used directly by a farmer or a cooperative of farmers (to share costs) Alternatively, they can be operated by a drone/technology company which is contracted by the farmer, Regardless of the ownership model, it is clear that drones will need to prove they can substantially and reliably improve upon existing processes before they are widely adopted

2.5.2 Quality of data captured

Most applications of drone technology rely on its ability to

generate and deliver precise and accurate information This data is then either used to guide direct activities like spraying, or to inform complementary activities like crop analysis and monitoring Consequently, data quality is crucial and should be core priority of drone use decisions, with aspects like a drone's speed and flexibility only secondary considerations. Given the relative infancy of agricultural drone technology, there is still much progress to be made For example, Chateau Lagrange, a vineyard in the Bordeaux region trailed drones and sensors and compared the measurements to reference figures they had compiled Whilst valuable information was gleaned, the technology was considered to be commercially premature 8 and not sufficiently reliable as a standalone solution It will as such be used in tandem with

traditional methods, as a complementary tool, until such time as the technology becomes more advanced Despite this, it is really only a matter of time until drone technology is mature enough to act as a replacement for existing methods, as the industry is rapidly integrating newer sensors, cameras and processing technologies, constantly improving the quality of the data captured

2.5.3 Ability of farmers to Access and Adapt to the drone technology

Widespread uptake of new technology requires farmers to adapt and modernize production practices in order to obtain the best returns on these investments With over 56 of the workforce aged over 55 in Europe 9 digital skills are often lacking, meaning that additional investment in training is often required. According to a 2017 survey conducted by the United States Department of Agriculture, 73 of farms have computer access, but only 47 of farms are using computers for business purposes 10 Furthermore, only 39 of farms use a smartphone or a tablet for farm business

This raises questions not only of access to technology, but of the level of inclination farmers have to use it in their work It's possible that possessing technology but choosing not to use it is a By-product of the general lack of digital skills and confidence found in older segments of the population, where farmers and other rural dwellers are well represented. This is an important issue to overcome, given that drones are usually controlled directly with digital tools (computers and tablets) in order to create the flight plan, and generate then analyse the gathered data

As a result, drone manufacturers are increasingly adapting their products, and developing autonomous features which require less tech savviness, flying skills/experience and infrastructure to operate effectively.

2.5.4 Legal and regulatory

Small UAVs are unmistakably different from aircraft in so many ways, yet they are considered as fully-fledged aircraft in most countries, which is perhaps the primary challenge impacting their governance. Few predicted how the UAV industry would reinvent itself so dramatically and become so far reaching in every enterprise and field of work. (Rambaldi & Guerin, 2017). The number of UAS now flying in Australia, EU and the USA is in the millions and recent studies indicate that they will increase exponentially across the globe. According to PricewaterhouseCoopers (PwC), UAVs will transform agriculture into a high-tech industry with decisions being based on real-time gathering and processing of data resulting in an increase in productivity and yields (Drone Powered Solutions, 2016). As a new technology, UAVs is evolving faster than the regulations intended to govern its use. Hence, the development and systematic updating of a regulatory framework fit for all, is a daunting challenge for all responsible authorities. A regulatory framework is needed for licensed drone pilots to be able to fly safely. For the regulator, it's a challenge to find the right balance between safety and flexibility. Safety must be a key priority at all times, but sometimes legislation (according to industry sectors) can be so strict that it limits drone applicability so their potential can't be fully realised. For example, flying beyond the visual line of sight; drones' real value lies in operating autonomously. The administrative process to request an exception to fly in a restricted zone takes a lot of time, limiting agility as drone flights have to be planned well in advance.

In summary, one of the challenges is the balance between the UAV cost and the performance. High performance of the UAV with long flight time, stability, as well as limited interference will be expensive and prevent farmers from adopting the application as they are very resistant to any new costs. The second challenge is that farmers need time to accept new technology and to be convinced that profits from this scheme are guaranteed.

2.6 Perceptions and Applications of Drones in Agriculture (in Africa and other ACP countries)

In October 2017, the Technical Centre for Agricultural and Rural Cooperation ACP-EU (CTA) in partnership with the NEPAD Agency, conducted a survey to understand the perceptions surrounding the use of drones for agriculture. Approximately 13,000 individuals (mainly English and French-speaking readers of CTA e-publications or members of CTA-managed communities of practice) received an invitation to participate in the survey. The aim was to understand the general perceptions on the use of drones amongst stakeholders in agriculture and development cooperation with an emphasis on African regions. 16%, or a total of 1432 individuals (of whom 91% have worked or are currently working in
Africa), completed the survey and had at least a working knowledge of drones in agriculture.
Language seemed to play a role from the survey as there are significant differences in terms of perception between French and English speakers. The French survey respondents showed a greater overall tendency to view agricultural drones less favorably than English speakers. This group of experienced users rated the use of drones to assess crop health as the most important function. The use of drones for stockpile volume calculations was seen as relatively less important than other applications, even though on average it was still rated as moderately important. Based on text answers, participants believed that there were especially opportunities to use drones in the monitoring and assessments of crops and livestock, in the management of pests and diseases, increasing crop production and in research activities. Drones were also often mentioned as useful tools surveying irrigated crops such as maize and rice and in the related management of water.

The results from the survey by CTA show that there is general optimism about the prospects of the deployment of the technology. 85% of survey participants said that they view the use of drones in agriculture favorably. They believe drones play an integral part in modernizing agricul-

ture and increasing yield and efficiency. Respondents consider that some of the most important applications include the assessment of crop health, the generation of topographical maps and the detection of varying rates of fertilizer applications on large holdings. In addition, the use of drones to detect and control pests and diseases, and the ability to rapidly collect information over large areas was most often cited as a reason for the favorable views.

Those that think less favorably about the technology most often expressed concerns that drones may not be an adequate tool to support current needs of smallholder and subsistence farmers. High costs and complexity of the technology were often perceived as challenges for its use by smallholders and less prosperous farmers. While agriculture is developed and modernized with the introduction of this technology, the interests and livelihoods of artisanal fisheries and smallholder farmers should be protected, according to some respondents.

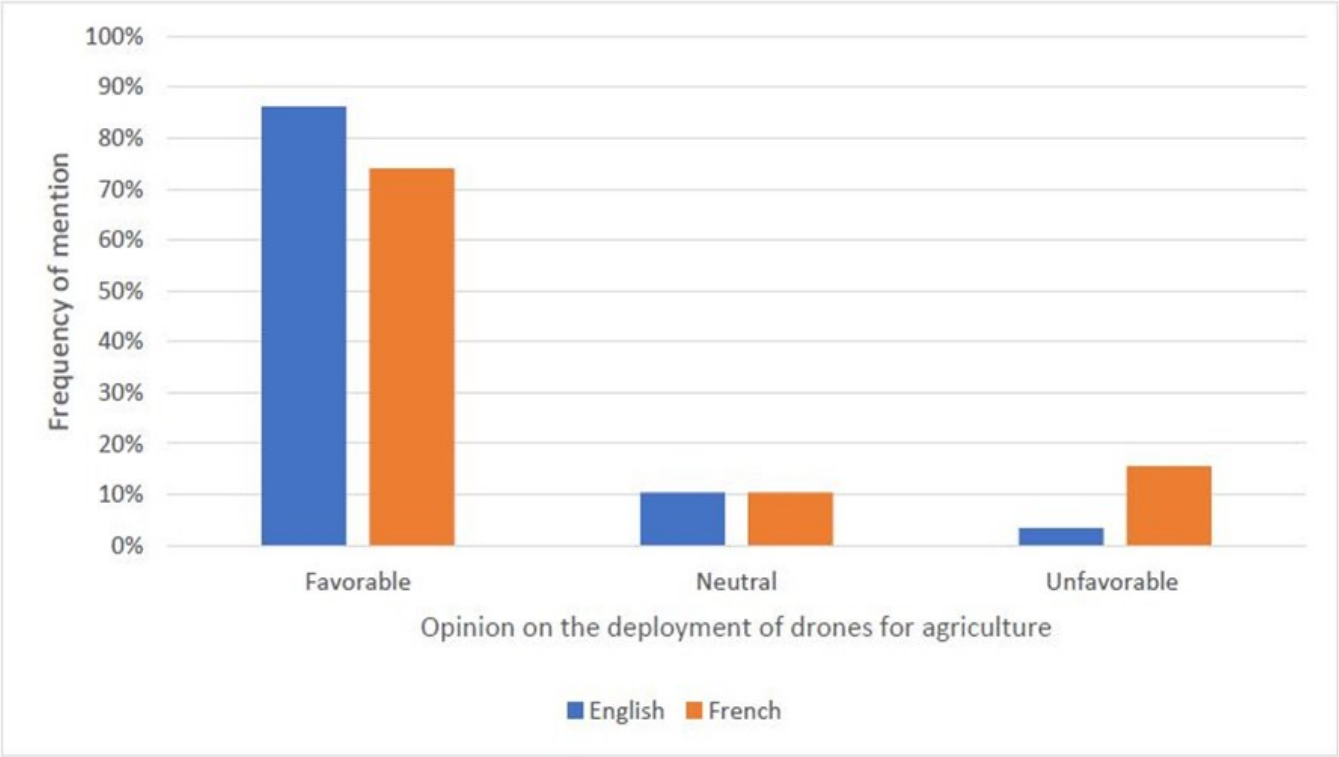


Figure 1: Perceptions based on language spoken by the respondent

Source: CTA 2018

3.0 Recommendations

After a detailed and elaborate discussion not only of the status of drones in Nigeria but also of the opportunities, the review listed the following recommendations:

- Ensure that stakeholders are engaged in all aspects related to the development of UAV technology so that potential resistance is understood and dealt with systematically.
- Conduct public awareness and capacity building around UAV's and their civil applications to clearly distinguish between civil and military uses. This approach will thereby improve public acceptance. Safety, security and privacy concerns need to be addressed as part of this process.
- Address cost and technical barriers to the adoption of the technology through either subsidy licensed SMEs or cooperatives, and build a supportive framework for drone governance and regulation to facilitate adoption (including licensing and registration).
- Encourage and support public-private partnerships for UAV technology uptake.
- Ensure that appropriate national UAV regulations are put in place. Relevant regulations should strike a balance between competing public security concerns on the one hand and the need to encourage innovation, economic development and youth entrepreneurship, on the other.
- Allocate financial resources for research and development (cost & benefits) and capacity building to form a critical mass in all aspects of drone technology – licensed pilots, scientists, regulators and relevant stakeholders.
- In the context of smallholder farmers, support crop intensification through stimulating the planting of the same crops simultaneously in contiguous areas to form more extensiveholdings which could reap the benefits of UAV technology for precision agriculture.

4.0 Conclusions/Future Scope

UAVs in precision agriculture are still in its early stage and maybe scope for further development in both the technology

and the agriculture applications. Providentially, it is expended that with the development of UAV'S technology, improved image processing techniques, lower costs, flying times, batteries, new camera designs, low volume sprayers, and nozzle types. A significant number of experimental studies of UAV'S based remote sensing for agriculture application. It will be a more prominent advantage of these systems in precision agriculture and environmental monitoring.

Drones can significantly improve agricultural produce and their condition in Nigeria. It can also provide real-time information on the state of pests that are invading farmer's fields. There is much room for growth with agricultural drones. With technology continually improving, imaging of the crops will need to improve as well. With the data that drones record from the crops, the farmers can analyse their crops and make educated decisions on how to proceed given the accurate crop information. Software programs for analysing and correcting crop production have the potential to grow in this market. Farmers in Nigeria should be able to fly a drone over their crops, accurately identify an issue in a specific area, and take the necessary actions to correct the problem. This gives the farmer time to focus on the big picture of production instead of spending time surveying their crops.

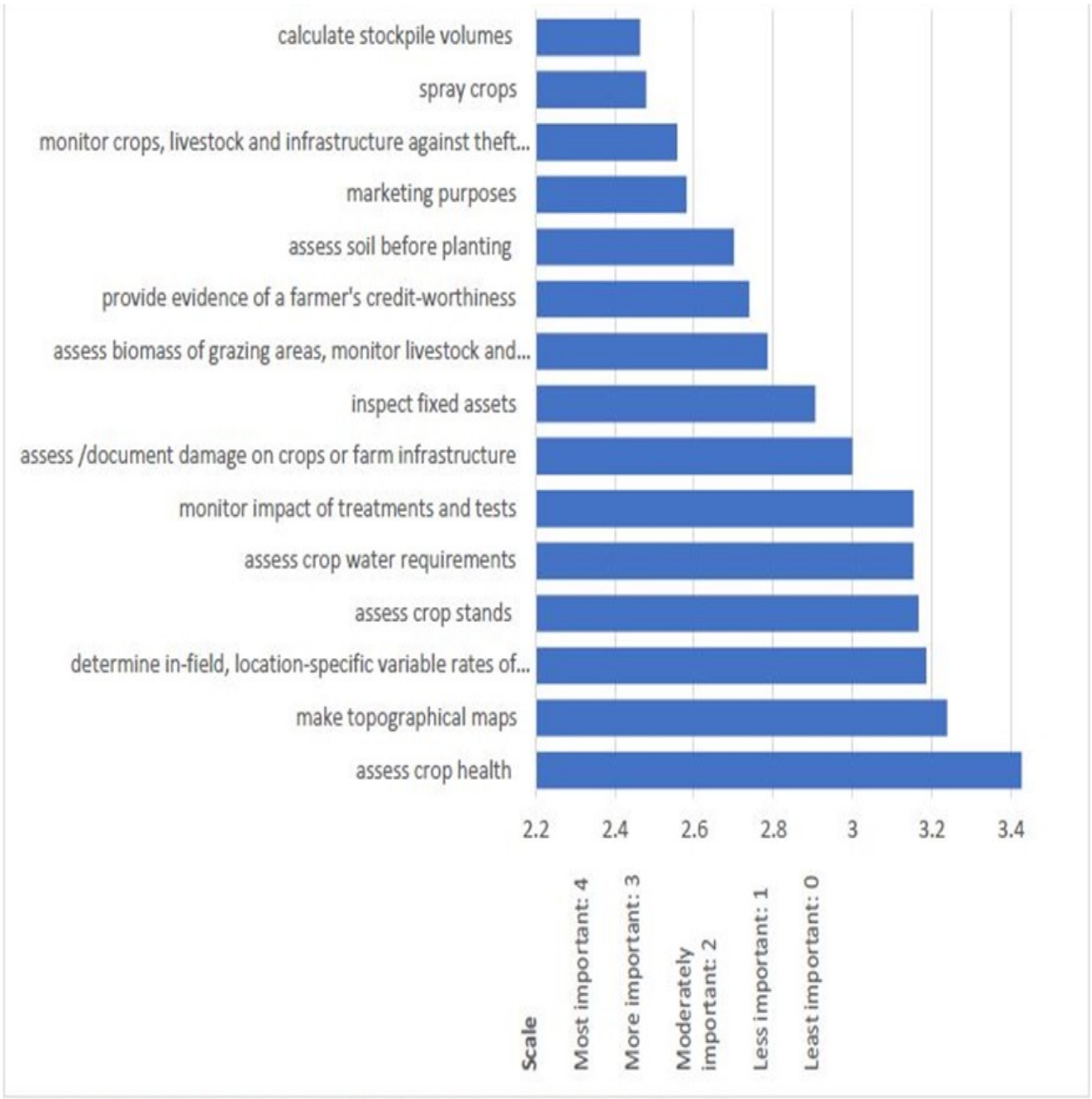
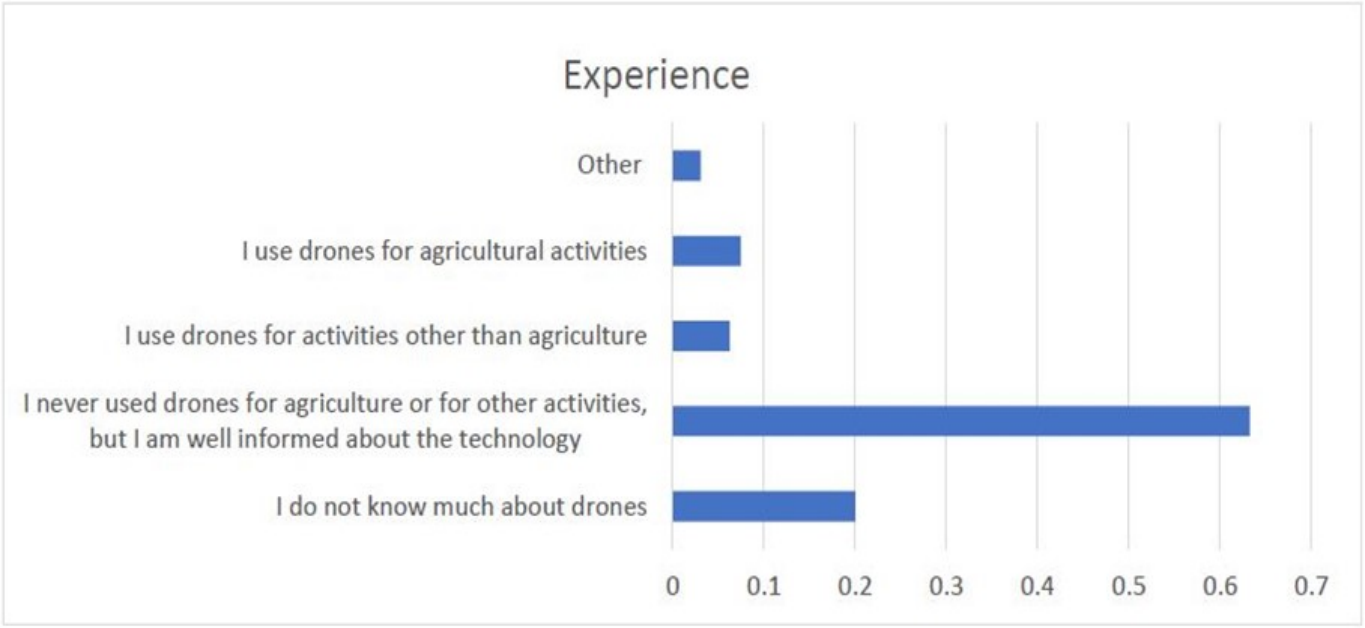
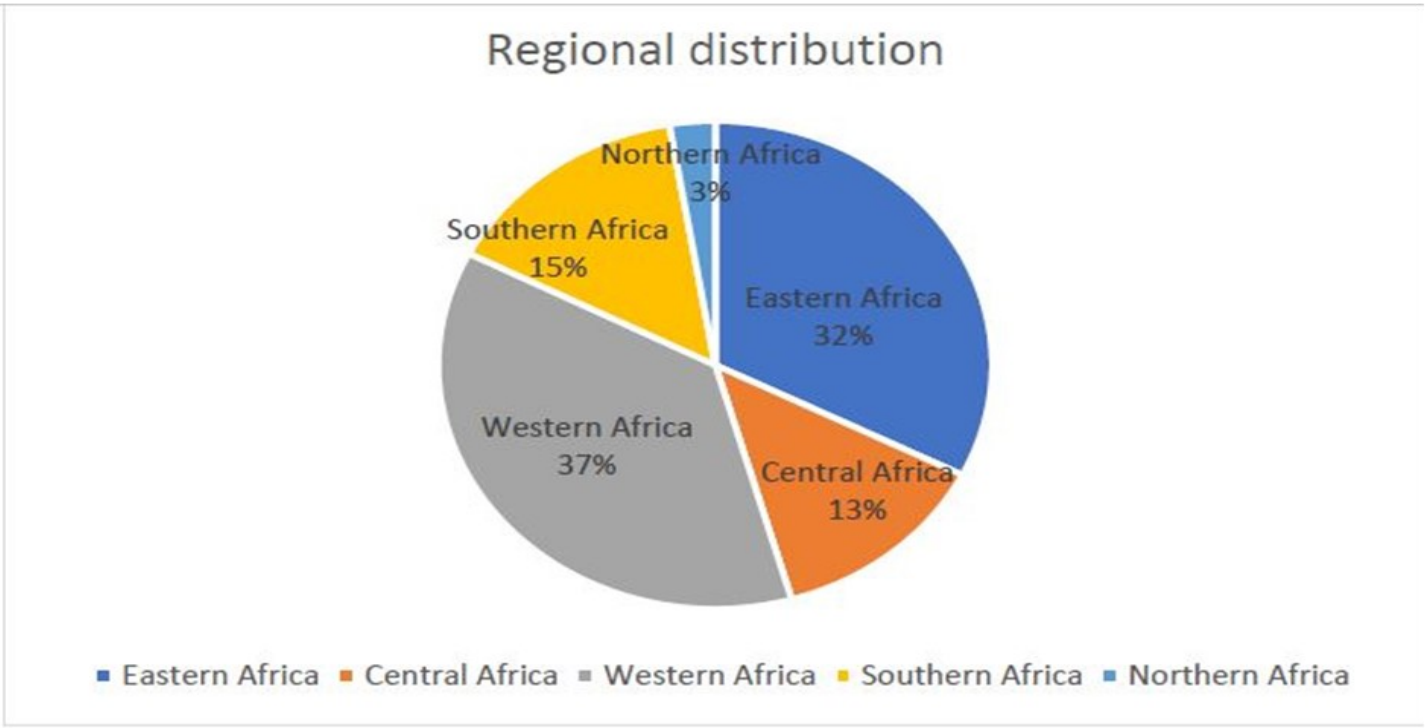


Figure 2: Perceived importance of activities according to experienced users

Source: CTA 2018





Eastern Africa	441
Central Africa	178
Western Africa	503
Southern Africa	201
Northern Africa	36

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