Afropolitan Journals

ISSN: 2730-7603X www.afropolitanjournals.com

Drone Agricultural Technology: Implications for Sustainable Food Production in Africa

Ajakaiye Olatunbosun Bolashade

Department of Agricultural Technology, School of Agricultural Technology, Kogi State Polytechnics, Itakpe, Nigeria.

Corresponding author: olatunbosunajakaiye3@gmail.com

Abstract

Today, there exist poor application of drone technology on African agriculture despite their low cost band small size. The drones have the potential to assist many African nations with rising economic development. Food production in Sub Saharan Africa (SSA) is on the decrease due to factors such as: drought, locust swarm invasion, regional conflict, Covid-pandemic, climate dependent agriculture, poor soil conditions, poor Irrigation water quality and quantity, logistic challenges amongst. The introduction of advanced technologies such as the drones can provide solutions to the aforementioned challenges. The technology would enable many farmers to practice precision agriculture. The drone technology can provide platforms to raise agricultural productivity while minimizing operational costs and improving use efficiency. The drone technology is applicable in agricultural activities such as: crop and livestock health monitoring, farm water management, soil and farmland assessment, precision crop spraying, bird control and simplified, and accurate planting of crops. The world over needs to raise food production by about 50% by 2050 to feed a growing population of about 9 billion people. Farming communities and actors in African agriculture must adapt to climate change and other challenges in food production for a sustainable drone technology.

Keywords: Drones (UAVs), Africa, Sustainable Farming, Challenges, Potentials.

Introduction

One of the latest technologies in agriculture is the use of Small Unmanned Aerial Vehicles (UAVs) called "drones". Drones are remote controlled aircrafts with no human pilot on board. Drone usage have a huge potential in agriculture in supporting evidence-based planning and in spatial data collection. The importance of drones in agriculture cannot be over-emphasized or over-exaggerated. The drone is applicable in the following areas: soil and farmland assessment, simplified and quality planting technology, precision crop spraying, farm crops monitoring, farm water management, livestock monitoring, crop health monitoring, livestock grazing evaluation amongst others. Despite some inherent limitations, which may include: illiteracy of farmers, poverty and bureaucratic protocols, non-accessibility and non- affordability of the technology to the smallholder farmers, these tools and technologies can provide valuable data that can be used to influence policies and decisions for sustainable food production sector in Africa (World Food Program WFP), 2017).

There is the need to feed the ever-increasing population of the African people and agriculture is the way forward. Agriculture in Africa has a massive social and economic footprint with more than 60% of the population of Sub-Saharan Africa (SSA) smallholder farmers, and about 23% of GDP obtained from agriculture (Food and Agricultural Organization FAO), 2021). Thus, the need to raise Africa's farm productivity from the rising food insecurity and poor agricultural output. The United Nations in 2022, stated that about 278million people in Africa lacked access to adequate food. A combination of several factors contributed to the poor farm production among which includes: drought, locust swarm invasion, regional conflicts, covid-pandemic, war in Ukraine, poor markets, logistic problems, climate dependent agriculture, poor farm inputs, poor soil conditions, poor irrigation water quality and quantity, and poor technology application and adoption.

From the foregoing, the poor agricultural food sector productivity can be improved upon through the adoption of advanced technologies such as the drones in agricultural production. There is the need to raise food production by employing these advanced technologies which can offer potential to face major challenges in African agriculture. The major application areas of the drones in agriculture includes: crop monitoring, soil and farmland assessment, bird control, precision crop spraying, farm water management, crop health monitoring, livestock monitoring amongst others.

Drones (UAVs)

Kancheti and Chandan (2017) defined drones Adam Unmanned Aerial Vehicles (UAVs) used to help optimize agriculture, raise crop production, monitor crop and livestock's emergencies and disasters, diseases and determine the amount of feeds in silos. Drones are remote controlled aircrafts with no human pilot on board. The drones are flying devices that can fly a pre-set course with the help of auto pilot and GPS coordinates. The device can be piloted manually in case of dangerous situations. The UAVs are used for model planes and helicopters with both fixed and rotary wings. The drone is a flying ROBOT which don't carry a human operator. The drone fan be remotely controlled or flown autonomously through software-controlled flight plans in their embedded systems working in conjunction with on board sensors and Global Positioning Systems (GPS).

Potentials of Drone Technology Usage in Africa

Drone technology could help farmers around the world to monitor their crops, fend off pests, improve land tenure and more. But to realize its full potential, regulatory regimes are necessary, while keeping citizens safety and privacy rights secure. While UAVs are unlikely to entirely replace manned aircraft or satellites, they have a number of advantages over the more traditional remote sensing methods. The technology is capable of collecting very high-resolution imagery below the cloud level, with much more detail than the satellite imagery usually available to developing country analysts. They are easy to use and most drone mapping and data-collection missions are now conducted autonomously. This makes

the drone to fly itself even as drone data processing tools are becoming less expensive and easier to use. Perhaps most importantly, drones are inexpensive. For instance, the drones are expected to provide significant helps to farmers in African countries, who historically have found it harder to access aerial imagery, either from manned aircraft or from satellites. The drones permit farmers to get a big picture view of their crops , allowing them to detect subtle changes that cannot be readily identified by "crop scouts" at the ground level. The drones are equipped with special sensors which can collect multispectral images that are stitched to generate spectral reflective bands. These bands allow users to calculate indexes such as Normalized Difference Vegetation Index (NDVI), Leaf Area Index (LAI) and Infrared (IR) and Photochemical Reflectance Index (PRI) images permitting farmers to view crop changes that are otherwise invisible to the human-eye. The NDVI provides information about the different biomass levels within a land parcel. The interpreted NDVI images can tell a lot about water stress or excess, nutrient deficiencies, pest infestation, crop diseases and other conditions affecting crop development. Imagery indicators such as NDVI, represents a first layer of information that can be built upon through field visits or a dedicated algorithm. Such algorithms are already available for fertilization where imagery indicators are translated into agronomic indicators to guide fertilizer inputs. This aerial data can also be used to speed up the painstaking process of conducting crop inventories and yield estimates. For instance, ranchers and fishery managers can use the drones to reduce the time and cost expended in conducting patrols and reconnaissance duties. The cattle ranchers can use the drones to locate their livestock over larger area of grazing land and to survey the livestock's fencing system (E-agriculture, 2018). drones also have proven useful to agricultural planners, greatly reducing the time and cost required to conduct volume estimates, to create irrigation and drainage models, to collect data needed to generate high-definition, geographically accurate elevation models and maps. The drones offer a range of exciting opportunities to improve the management of crops, livestock, fisheries, forest and other natural resources. The drones can be used to document illegal land and resource use through gathering images of illegal logging and land occupation by government agencies. The drones create opportunities for ICT managers to support the agricultural sector usually by engaging youths to embrace and adopt the UAV technology.

Challenges of Drone Technology in Africa

Despite the great opportunities offered by the use of drones to initiate dramatic changes and improvements in the agricultural food sector in African countries, it is not without challenges. Some of the challenges includes: high level restrictive rules and regulations governing the importation and use of drones can hinder the development of sustainable industry, which could attract and engage educated youth in rural areas. Youths are attracted by new technology, it's development and usage. The drones could be a magnet for educated youths in Africa to develop service enterprise business in rural farm areas, thus generating job opportunities and improving agricultural production and farmers returns on

investment. Another challenge is that drones are not widely used in African agriculture, drone cases are still being investigated and tested by the industry due to high cost o acquiring it. Drone usage is still at unit infancy stage as data gathering devices, there is the need to establish successful acquisition of data and data multiplication techniques which are highly significant in transforming such data into relevant information. The small size of the drones limits its inputs; thus, their uses are limited to simple aerial imagery and visualization (short flight time). Furthermore, the sustenance of the battery technology needed to improve flying time above 30 minutes, not efficient where other technologies are working but in areas where other technologies are not accessible, for example in hilly areas. In some nations, aerial spraying may not be permitted under insecticide Act, drones may be dangerous to spray hazardous chemicals. There is no standard operating and technical protocols to operate UAVs safely dye to poor security and violation of people's privacy. The technical know-how, system integration, data analysis of high performance systems, transmission of information and machine learning application to operate the drones are still lacking. There is the need to overhaul the drone usage legislation and interpretation of the laws guiding the operation of the drones in the aviation industry to enhance its adoption. Finally, the issue of training integration and deployment is at higher cost, this also include high cost of purchase and maintenance at higher cost.

Theoretical Framework

This review adopted the theory of technology diffusion as the theoretical framework. Following the literature by Young (2009), the model of technology diffusion focused on learning from experience, either own or that of others while giving prominence to the network of connections that is available to the farmers. The technology diffusion model assumes that people adopt new technology when they come in contact with who have already adopted.

Drone Technology Application Areas

The drone technology is applicable in wide areas or fields of life. The following are the areas that has developed usage of the drones.

- Emergency services which responds to natural or man-made disasters, which reduces expenses on manned aircrafts and creates larger aerial view which may be inefficient for emergency rescue mission
- Cinematography and film industry to capture scene or footage in films which are more efficient than helicopters, cranes and aircrafts meant for the same purpose.
- Disaster rescue and search with thermal sensors attached, drones can work at night as tool of surveillance to discover the locations of endangered people.
- Law enforcement services, with powerful cameras and thermal sensors to monitor the activities of criminals, drug smugglers, illegal deals on borders and waterways.

- Delivery services management to transport and deliver small packages such as foods, parcels, letters, medicines, and snacks over short distances.
- Wild life management to monitor and manage wild animals such as elephants, lion, tiger, buffalo from poachers.
- Military services on land, water and in the air to manage difficult locations such as forest, turbulent waters, difficult terrains, risky locations before troops are dispatched to such areas.

Drones Flights

The typical agricultural drone is made of the following parts: Frames, controller systems, propulsion systems, navigation systems, power systems (batteries), and other components such as wires, connectors, carry cases, sprayers, and sprinklers (Debangshi, 2021).

The drone is controlled manually with hand-held radio control transmitter controlling the propeller manually. The sticks on the controller allows movements in different directions and trim buttons allow the trim to be adjusted to balance the drone. The screens can be used to receive live footage from on-board camera and for sensor display. The on-board sensors provide helpful settings to auto-altitude where the drone will move at fixed altitude. This also provide helpful settings when drones remain at a fixed GPS position.

Agricultural Drones and General Rules

The following are the types of drones used in agricultural practices. The fixed wing drones, rotary wings drones, lighter-than-air (LTA) drones, and tethered vehicle (FAO, 2018). According to Food and Agricultural Organization (FAO), 2017), The general rules for the use of drones in includes the following:

- Drones should restrict operations to sparsely populated locations.
- Drones should be flown at day time and under clement weather conditions.
- Drone usage are prohibited in government or military formations unless permission is granted.
- All trained drone pilots must not be less than 18 years of age.
- Only one trained pilot should control one UAV at a time.
- Drones should not be flown within 50km of a nation's border.
- Drones must be flown more than 500m out to sea from the coast.

Roles of Drones in African Agriculture

Food and Agricultural Organization (2016) stated that drones are useful in various fields ranging from the military, humanitarian relief, disaster management to agriculture. Drones facilitates quick data collection with greater accuracy while providing a safer monitoring system in farm emergencies and also makes remote sensing data more efficient and accessible. This quality data access is to make effective policies and interventions towards the achievement of the sustainable development goals by 2030. Drones are widely used in

agriculture to determine crop biomass, growth and production pattern in analyzing precision application of input resources, harvesting of crops and logistic optimization. The drones play several roles in agriculture among which includes:

1. Soil and farmland assessment: Drones are used to collect data before and after planting. These data obtained are useful in analytical planning of crop species to be down, pattern of planting and determining the amount and time of irrigation and nutrients applied. These management decisions at the farm level can improve the overall productivity of the farm.
2. Simplified and accurate planting technique: Drones influence simplified planting of crops usually on very large scale. This is characterized by accuracy and exactness within a short time duration. The drone usage can alleviate the problem of ever expensive and burdensome traditional human labor which is readily available, by reducing the planting cost and strenuous energy wastages on ground planting approach.
3. Precision crop spraying: Drones are equipped with sensors which can scan cropped area on real time basis while enduring precise quantity of chemicals (pesticides, herbicides) are sprayed on the target locations. Record estimates have shown that drones can complete aerial spraying up to five times faster than those of conventional spraying. This is achieved by enhancing accuracy in spraying, saving time and input costs of farmers and reducing pesticides pollution in ground water.
4. Crop monitoring: One of the roles of drone usage in farming is its simplicity and efficiency of massive scale surveillance of crops and farmland. One of the crop production challenges is the unpredictable weather extreme which creates obstacles in field monitoring. Today, drones' animations of time series situations can provide precise development of crops and also reveal production inefficiencies, while enabling better crop management.
5. Farm water management: Agricultural drones when equipped with thermal sensing cameras which have the capability to offer phenomenal perspective into particular troubled areas of the farm for irrigation water application. These insights can be monitored through the attached digital cameras from low moisture stressed condition to water logged conditions, thus allowing farmers to employ Irrigation management decisions based on the water status of the soil. This leads to precision application of water on the farm.
6. Crop health monitoring: The drones uses the green visible lights along with near-infrared light to scan the crops for assessing disease incidence in spatial and temporal variation based on crop reflectance. Crop health monitoring is very essential to detect crop, bacteria, viral and fungal diseases. The early detection of these crop diseases is possible to make in before interventions to safeguard the crops by tracking changes in crop growth by specifying their health status.

7. Livestock monitoring: Drones are equipped with several potential applications in animal husbandry. Each farm animal is tagged with sensors or radio-frequency identification (FRIDs) tags to monitor feeding activity and their movements. The drones are used to track livestock's in much higher frequency, with in a short time and investment in personnel. Remote- sensing fencing, virtual boundaries or remote sensing-zoning essentially means in creating a virtual obstacle or security fence across spatial area of interest especially in free-range practice of livestock grazing.

Implications of Drone Technology Usage in Africa

The leverage of drone technology in Africa is for farmers to be able to use the technology bro deliver sustainable agricultural systems that can feed the continent and also achieve the United Nations Sustainable Development Goal of zero hunger. The drone usage is a very sustainable and practical option, as it has the capability to improve food security and increase productivity. Drones are becoming that defining piece of technology which enable farmers to make better decisions regarding the management bit their farms. It is worthy of note that inefficient pest and weed management during crop production contributes to 40%-80% and 37% loss in crop yield respectively, and at the same time, reduces crop quality and farmers revenue. However, the opportunities provided by drone technology outweighs the shortcomings and have-a long lasting positive impact on the food security in Africa. Modern technology is a way to ensure that food production is not seasonal, because we understand that hunger is not seasonal (Ogbole, 2020). Food technology would break the seasonality of food production in Africa.

Future of Drone Usage in Africa

To predict the future of drone technology in agriculture is an unavoidable task because of the many promising trends and pilot projects. Analysis of the drone data is becoming increasingly automatic, as intelligent computer systems are growing in identification of different crop varieties, mapping and categorizing weeds as well as assessing crop damage from pests. Automated analysis may also make wide-scale agricultural mapping a lengthy process, helping analyst to detect more accurately signs of impending famine and crop failure. Drones can be developed for precision crop spraying mission, enabling farmers to use chemicals in smaller amounts and minimizing human contact with dangerous substances. The drones can also be developed for search and destroy pest control missions, identifying pests and wiping out particular destructive pests. The drone technology could be used to quickly determine the distribution of livestock enabling veterinarians to quickly find animals that may be infected with ailments like "foot and mouth" disease (FMD) or enabling farmers to swiftly identify the movements of larger crop pests. The drones may also be developed to help farmers in Africa to monitor their crops, plan their farms and fend off pests. Drones imagery can also be useful in giving accurate estimate of loss of crops or livestock's or farmland (Wadke, 2017).

Conclusion

This study reviewed drone technology and its implications for sustainable food production among smallholder farmers in Africa. The study concluded that drone technology usage among African farmers is still at the infant stage and need to explored if sustainable food is to achieved. The future of agricultural food sector in Africa is to guarantee consistent increase in quality and safe food for its ever increasing population, and this can only be achieved when all factors hindering productivity are effectively addressed and the solutions are optimized with the use of technology like the drones.

Recommendation

One of the reasons for drone usage in African agriculture is to explore the possibility of an unending food production, increased farm growth and improved development of smallholder farmers through poverty alleviation. The following are recommendations for policy makers and all actors in the agricultural field.

- The development agencies should research more by experimenting on drone technologies where this aerial technology will be made available and accessible by all African farmers.
- Actors along agricultural chain and lawmakers should work together to develop ethical and reasonable regulatory laws that will make drone usage legal, while maintaining individual citizens safety and privacy rights secure.

References

Adewopo, J. (2017). Regulations and realities in Nigeria's UAV airspace. Retrieved from CTA Corporate: https://goo.gl/onFRQB on 17-10-2022.

Ajewole, P., Elegbeleye, K., and Oladipo, I. (2016). The prospects of precision in Nigeria.

Amico, L. (2017). Ask a drone lawyer. Harvard Business Review. http://hbr.org/2017/05/ask-a-drone-lawyer.

Barbedo, J.G.A. (2019). A review of the use of Unmanned Aerial Vehicles and Imaging Sensors for monitoring and assessing plant stress. Drones, 3(2), 40.

Blein, R. (2013). Agriculture in Africa: and Outlook. NEPAD.

Debangshi, (2021). Drones application in agriculture. Chronicles of Bioresources management 5(3); 115-120.

Department of Homeland Security, (2018). Cyber security risks posed by Unmanned Aircraft Systems. Critical infrastructure security and pestilence notes. May 22, 2018.

Drone power solutions, (2016). Clarity from above. PWC global report on the commercial application of drone technology. Warsaw: PWC.

Efron, S. (2015). The use of Unmanned Aerial Systems for Agriculture in Africa. Can it fly? Santa Monica: RAND Corporation. Retrieved on 15-10-2022.

FAO, (2018). E-agriculture in action- Drones for Agriculture; Available at http://fao.org/document/card/en/c/I8494EN. Accessed on 20-10-22.

FAO, (2017). Drones for Agriculture; Available at http://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1234537. Accessed on 20-10-2022.

Gilman, D. (2015). Unmanned Aerial Vehicles in Humanitarian Response. Policy development and studies branch, United Nations office for thecoordination of Humanitarian Affairs (OCHA). http://www.microdrones.com/en/industry-experts/

Jeanneret, C. (2016). Making sense of drone regulations. G ICT Update, pp 22-23.

Matthews, G.A. (2000). Pesticides application methods (Black well science: Oxford).

Mahlein, A.K. (2016). Plant disease detection by Imaging Sensors-parallels and specific demands for precision agriculture and plant phenotyping. Plant disease, 100(2), 241-251.

Miller, O. (2003). The measurements of spray drift pesticides outlook, 14:205-09

Pravin, K., Munde, T.N., (2019). Use of drones for efficient water management. 3rd World Irrigation Forum. 2(5), 1-7.

Rao Mongili, U.M., and Deepak, B.B.V.L., (2018). Review on application drone systems in precision agriculture. Procedia computer science 133(2018) pp 501-509.

Volkmann, W. (2017). Small Unmanned Aerial Systems mapping versus conventional methods: Case studies on farmland surveying. Wageningen: CTA