The Socio-Economic Benefits and Impact Study on the Application of Drones, Sensor Technology and Intelligent Systems in Commercial-Scale Agricultural Establishment In Africa

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Abstract

This study discusses the various uses and general impact of drones, sensor technology and intelligent systems in agriculture or precision agriculture and brings to light the socio-economic benefits of their application in commercial-scale agricultural establishments in Africa. It also provides evidence of the application of these methods on farms in some countries in Africa and the benefits derived. The study draws the attention of both small- and large-scale farmers and other stakeholders in Africa and the world, who wish to engage in commercial-scale agriculture and make them realize the importance of employing this type of technology in their agriculture fields. It also draws the attention of governments and policy makers who wish to improve the agriculture sector to consider these impacts and provide some form of regulatory regime to ensure the safety and privacy of citizens in relation to their application.

Keywords: Agriculture, drones, economics, intelligent systems, policy makers

1. Introduction and Background to Study

The agriculture sector is one of the most important sectors in most economies, as it provides some of life's necessities. Most economies would go down without agriculture. Africa, as a continent is not left out, since it also depends largely on agriculture for the survival of its citizens, from employment creation to providing food for the economy (thus, helping to solve the problem of hunger and food insecurity as well as poverty). It is very essential to some of the biggest

developmental goals of Africa and a catalyst for job creation (Ehui, 2018). According to NEPAD (2013), the agricultural sector in Africa continues to employ the highest proportion of the labour force. The sector alone employs about 65% of the labour force in the continent and contributes a lot to GDP, accounting for 32% in 2016 (Mayaki, 2016). However, the sector in Africa was not employing smart methods of production until recently. It depended massively on weak methods of production that has proved to be difficult to apply. Examples are the dependent on rainfall pattern for production, the use of local and unproductive instruments such as cutlasses and hoes against the use of more improved and modern technological methods as well as the cultivation of products that yield less profit. All these, among other problems serve as a deterrent to individuals, especially the unemployed youth and graduates and thus, prevent them from wanting to engage in agricultural production in Africa, especially at the commercial level.

Recently however, there is an ongoing development in the methods used in agricultural production that brings about increase in productivity. One most important method that is being adopted is precision agriculture which allows agriculture producers to use smart methods and modern technology in agriculture production. Precision farming as defined by some scholars is "a farming management technique that is based on observing, measuring and responding to intra and inter-field variability in crops." Roberts (2007) defines precision agriculture as a set of farming methods done with the aim of achieving agricultural sustainability based on the right application, right amount, right time, and at the right place

According to Turner *et al*. (2016), precision agriculture helps farmers to make judicial use of their chemical inputs such as herbicide and fertilizer thereby saving on them and protecting the environment from excessive chemical pollution. Some of such methods are the application of drones, sensor technology and intelligent systems in production, especially at the plantation or commercial level. This method has long been adopted by the advanced countries in their agricultural production and has proven to be cost-effective, efficient and more profitable (Kan, 2013; Turner, 2016). Its positive impact on the society and the economy is also substantial. Some studies, such as Jenkins and Vasigh (2013) highlight the benefits that could be derived from the application of UAVs in agricultural establishments. It comes with technology that helps the farmer right from the beginning of cultivation to harvest of produce with some positive social and economic impact.

Some African farmers and ranchers who produce on commercial basis not long ago are now adopting such techniques of production (application of drones, sensor technology and intelligent systems) on their farms and ranches. This however seems not to be enough since most of them still use the traditional technique which comes with lots of risks and great loss during disease outbreak and drought. Lots of benefits that could be derived from the application of this technique have been outlined and discussed by most scholars. However, the social and economic benefits, as well as the impact study of such methods in Africa seems to have received little attention.

It is in this pursuit that this study seeks to analyze the socioeconomic benefits and impact study on the application of drones, sensor technology and intelligent systems on commercial-scale agricultural establishments in Africa.

This study would bring to light the socio-economic impact of the application of drones, sensor technology and intelligent systems in commercial-scale agricultural establishments across the African continent. It would also provide evidence of the application of these methods on farms in some countries and the benefits derived. This would draw the attention of both small- and large-scale farmers and other stakeholders in Africa who wish to engage in commercial-scale agriculture and make them realize the importance of employing this type of technology in their agriculture production. Lastly, it would draw the attention of governments, policy makers and other stakeholders who wish to improve the agriculture sector to consider these impacts during their decisions and policies relating to the sector.

2. Sensor Technology, Intelligent Systems and Drones (Unmanned Aerial vehicles). Their Uses in Agriculture and Literature.

Image of an application of agricultural drone with smart sensor onboard on an agriculture field

Drones, also referred to as unmanned aerial vehicles (UAVs) are aircrafts which do not have pilots aboard but are controlled remotely by human or fly automatically through software-controlled flight procedures in their embedded systems. They are mostly used together with GPS and smart sensors onboard. Drones, sensors and intelligent systems were originally employed in missions which were very dangerous dull or dirty for humans and were mostly used in military applications. Their used are recently however expanding to scientific, commercial, agricultural, recreational and other applications such as surveillance, policing, product delivery, peacekeeping and aerial photography.

There is an upsurge in their application in agricultural establishments around the world recently. Agricultural drones, sensors and intelligent systems are the new trend in agricultural establishments that is being employed in most commercial-scale farm projects around the world, with numerous benefits being derived. They are revolutionizing agriculture production across the globe and making the sector more attractive to all, both young and old, governments and individual citizens. However, their application in Africa is now in the early stage as farmers across the continent are now being introduced to them. Some of them are even ignorant of their existence.

2.1 Application of drones, sensors and intelligent systems in Agriculture productivity

In commercial-scale agriculture, drones with smart sensors onboard and other intelligent systems can be used in diverse ways to bring numerous benefits to the producer (Hunt Jnr. & Daughtry, 2018). Some of the ways in which this form of technology is being used in agriculture production are discussed below.

2.1.1 Soil or variable-rate fertility analyses

Any agricultural producer would always want to know the nature of the soil or field before cultivation or planting. With this, they first do analyses of the soil or field to know the amount of nutrients and moisture (Hunt Jnr. & Daughtry, 2018). Drones and smart soil sensors can be employed to provide effective analysis with a more accurate result. They produce a 3 – dimensional (3-D) maps for soil analysis which can be important in planning various patterns for seed planting (Mazur, 2016; Puri *et al.*, 2017; Hunt Jnr. & Daughtry, 2018). The analysis done by using the drones can also provide data for managing the amount of nitrogen and irrigation after planting crops. According to Grassion (2014), variable-rate application (VRA) maps produced by drones and sensors to determine the strength of nutrient application contained by a single field, the agricultural producer can apply 60 pounds of fertilizer to the struggling areas, 50 pounds to the medium areas, and 40 pounds to the healthy areas to help in judicious use of fertilizer.

2.1.2 Planting of crops

Cultivating hectors of land could be hectic, time wasting and very costly, especially during planting. Planting could be very difficult when done manually. This particularly makes agriculture production expensive and unattractive to most individuals, especially the youth. The application drones, sensor technology and intelligent systems make planting on commercial basis very easy. This is because some drones have planting systems that can plant seeds directly in the soil. This is done by loading seed pods on the drone and firing them from it into the soil. Some drones can plant about 100,000 seeds in a single day (Gayde, 2018). This makes planting products on hectares of land very easy, efficient, cost effective and saves enough time.

2.1.3 Crop Health Monitoring

Scouting fields of crops manually to examine the health of crops and other necessary infestations could be very difficult and time consuming. Drones, sensors and intelligent systems are also use in monitoring the health of crops. They have the ability to accurately examine the progress of crops, in relation to weeds, pests', diseases and other risks that may affect crop growth and production (Vark, 2015). This is mostly referred to as scouting. This is done specifically with the Near-infrared (NIR) sensor or the Normalized Difference Vegetation Index (NDVI) sensor. With the application of UAVs and other intelligent systems, farmers can better track the health of crop, transpiration rates and sunlight absorption rates through crop health imaging which is done by using Infrared, NVDI and multispectral sensors (Puri, et al., 2017). According to Hunt Jnr. & Daughtry (2018), the small earth sample distances obtained by using UAS allow farmers to visually detect weed occurrence, disease outbreaks, and insect infestations.

2.1.4 Irrigation and Crop Spraying

Spraying about 10000 acres land of crops could be very tedious, expensive and time consuming, even with agricultural machinery. Another use of Drones and sensor technology, as well as intelligent systems is spraying of crops, either with water or fertilizer. Drones with thermal sensors can identify which areas of the field needs irrigation. They can also assist in the calculation of vegetation index that remotely estimates the water and nutrient contents of soil, monitor evaporation and crop transpiration (Puri *et al.*, 2017; Hunt Jnr. & Daughtry, 2018).

Image of a drone spraying crops

They help reduce excessive amount of fertilizer and water by scanning the fields and spraying the right amount on crops and areas that need them. According to Mazur (2016), UAVs can scan the field and spray the precise amount of liquid, controlling distance from the ground and spraying in real time for smooth coverage. They can help make spraying easier, faster and cost-effective.

2.1.5 Livestock Monitoring and farm safety

Image of livestock grazing on a field captured using drone with sensors

Rearing livestock at the commercial level could be very hectic, time consuming and very costly. For instance, herding and what is normally called “direct scouting” of animals is one of the most important but difficult thing to do during commercial-scale livestock production, especially when done manually.

The application of drones, sensor technology and intelligent systems can make livestock production very easy, efficient and cost effective. UAVs can be used in livestock monitoring.

Drones with thermal sensors are mostly used in detecting sick animals. A farmer with UAVs needs not to worry about having to follow livestock throughout the time with the aim of keeping an eye on them. With the help of drones with thermal sensors, the farmer can know exactly what goes on in the fields as well as detect the health of the animals without having to go to the fields or be there throughout (Vark, 2015; Schultheis, 2017). They can capture every image of the field and provide efficient information on the livestock within a short period of time.

3. Evidence of Some Applications of Drones, Sensor Technology and Intelligent Systems In Agricultural Establishments in Africa

Recently, there has been evidence of the application of UAVs in some agricultural establishments in some African countries. This part of the study highlights and discusses these developments in the continent, in relation to the benefits derived.

Firstly, there is an evidence of the application of UAVs by the International Potato Center (IPC) in collaboration with the national Bureau of Statistics in Uganda and Tanzania. It was realized that, drones are able to find accurate and a more effective data that could help farmers in diverse ways such as the ability to gain extension services like training, seeds or micro-insurance (Vark , 2015). According to Allen (2016), the analysis done in Tanzania showed that remote-sensing done by using UAVs with multispectral cameras can improve upon some rough estimates made by crop statisticians. It was realized that this could help in budget allocation and planning.

More so, according to Le (2016), drone helped farmers with a cost-effective way of planning, design and construction of rice irrigation systems in Nigeria. The growmoreX team of the GMX Consultancy based in London went to Nigeria to do a preliminary assessment for the development of 3,000 hectares irrigated rice farm by using UAVs. According to their assessment, the UAVs did

a fast and accurate job by surveying and mapping about 1000 hectares of land in just a day, which is assumed to have taken a surveyor working manually about 21 days (Le, 2016). In the end, the UAVs provided beautiful and accurate images of the area as well as data for assessment and quickened the planning, design and construction of the irrigation infrastructure in Nigeria (Le, 2016). This confirms the argument about UAVs providing accurate information, saving time and being cost effective.

Lastly, there were research projects that were carried out in Ghana and Kenya on the application of UAVs in agricultural monitoring by the University of Lund and Swedish University of Agricultural Sciences. They combined observations from UAVs, biophysical investigations and conventional infrared spectrometer technology in accordance with existing survey data on village and farm household characteristics that were taken during the period 2002 – 2014 (Hall, 2016). Their research revealed that the aerial images provided by the UAVs have a higher spatial resolution than those produced by most satellites and showed crop details (Hall, 2016). This confirms that, UAVs can help farmers and stakeholders of agriculture to know the causes of low crop productivity.

4. **Main Findings**

Imagine planting crops and being able to see what goes on in your farm of about 5,000 hectares and the activities of the livestock that go grazing the fields in one certain or at a go without having to go to or tour the entire land? Thus, you are able to plant seeds and know when and which part of the farm needs irrigation and pesticides, provide precise amount of fertilizer, what happens to the livestock or any intrusion from a distance without actually going to the farm? That is what happens when a farmer employs the use of drones, sensor technology and intelligent systems in

agricultural production. This system normally improves agricultural productivity, both in crop or livestock production. This in turn impact positively on poverty reduction, exports and industrial development, increases demand for and supply of drones, sensor technology and intelligent systems and eventually improves economic growth in general. This part of the study provides discussions on some of the general advantages and socioeconomic benefits that could be derived from the use of drones, sensor technology and intelligent systems in commercial-scale agricultural establishments in Africa.

4.1 General Benefits:

4.1.1 Reduce crop damage and Increase Yields

To be able to increase productivity and harvest healthy crops, it is always important to assess the health of crops from time to time. As discussed earlier, drones, sensor technology and intelligent systems can help do this effectively and efficiently. Their applications in commercial-scale agriculture help identify problems before they happen. With this, problems such as diseases that may affect crops or have already affected some parts of the crops in the farm would be dealt with early before they spread to other areas of the farm. This helps increase crop health efficiency and awareness and eventually improves production efficiency and brings about higher yields (Margaritoff, 2018: Hunt Jnr. & Daughtry, 2018; Puri, *et al.*, 2017).

The aerial data can also help during crop inventories conduction and yield estimates which are difficult in manual agricultural production.

4.1.2 Reduce risks involve in and increase production of livestock production

As mentioned earlier, external sensors can help in tracking movement patterns of animals to determine their fitness and health. They can also help identify optimal times of breeding and sensing physical injuries.

With this, a farmer can use the available information or data provided by the UAVs and sensors for monitoring, management and safety purposes. This type of technology can also detect fires and help with safety needs of the farm. They can provide the farmer with the necessary information and alert in the event of fire out-break on some parts of the farm before it spreads across the entire farm (Vark, 2015; Schultheis, 2017). They can also alert the farmer when there is an intruder in the farm or on the fields that plans to either harm the livestock or crops or even causes theft.

4.1.3 They save time and are easy to use

One most important benefit of using UAVs and intelligent systems in agriculture production is their ability to scout the farm to ensure whatever is needed or is going on in there efficiently and very fast (Puri, *et al.*, 2017).). Some scouting may sometimes take days when done manually and may also be very hectic, expensive and time consuming on the part of the farmer. The use of drones and other artificial systems make working on the farm very easy and save time. With UAVs, information on the farm could be gathered within a shorter period of time and at any time the farmer wants without having to worry about efficiency and helping to make quick management intervention. This serves as an encouragement to the agricultural producer to produce on a larger scale without fear of being stressed-out about having to scout the field manually when necessary. This brings about increase in production and yield.

4.2 Socioeconomic benefits:

There are lots of socioeconomic benefits that could be derived from the application of drones, sensor technology and system intelligence in commercial agricultural production in Africa. Some of them are poverty reduction, increase in export and reduction in import, employment creation, and improvement in economic growth of the continent.

4.2.1 Reduction in Poverty in Africa

Agriculture has the potential to reduce poverty in Africa (Mayaki, 2016). Increase in the crop yields would to some extent help solve the problem of poverty in Africa. Poverty is mostly described as a situation where an individual or a household cannot afford three square meals or do not have the ability to afford a balance diet over the day. The increase in yield on commercial basis would mean producers would supply of such produce. According to the economic assumptions and principle of supply, the prices of goods reduce when the supply is high against demand, all other things being equal. If this assumption holds, commercial-scale producers of agricultural produce, through the use of UAVs would supply more produce at low prices but with more profits due to the cost-effective nature of the application of UAVs. This would help even the poor that couldn't previously afford such produce be able to, thereby bringing them out of poverty and reducing the poverty level of the African region to some extent. More so, the increase in employment would also increase the standard of living of people and eventually reducing poverty.

4.2.2 Improves Balance of Payment in Africa

According to research, Africa as a continent continues to import agricultural products from other continents. This is because, since most producers produce on subsistence basis, the agricultural products produced are not enough to meet the demands of the continent hence their importation to make up for the deficit. Imports of goods to other countries normally have it downside, especially the negative effects they have on the balance of payment and the economic growth of recipient countries. This makes the currencies of the recipient countries suffer depreciation against the trading foreign currencies in the world market.

However, if there could be an alternative and smart way that would help Africa to produce more agricultural products on commercial scale, there would be enough produce to the extent of exporting some to the world and eventually help to improve its balance of payment.

One smart way is to introduce and encourage the application of drones, sensor technology and intelligent systems in commercial-scale agricultural establishments in Africa. As stated earlier, the use of UAVs in agricultural production reduce crop damage and increase yields. With this, farmers would be encouraged to cultivate on commercial-scale and come up with increased production eventually. Since farmers are producing on larger scale there would be enough agricultural produce with which some could be exported to other continents and imports of these produce to the continent could be reduced. Increase in export of and reduction in import of agricultural produce in Africa to some extent would help solve some of the balance of payment problems in the African economy.

4.2.3 Environmental Protection and Water Efficiency

Water is gradually becoming a scare resource in Africa due to climate change and the activities of individuals, such as "galamsey" in Ghana and other African countries, which is gradually destroying water bodies that serve as the most important source of irrigation for agriculture aside the dependent on the rainfall pattern. Having proper irrigation system in agricultural establishments in Africa is one of the problems that are being faced by the sector. More so, most producers with larger agricultural lands find it difficult scouting the entire farm to assess the exact places that need irrigation and fertilizer and the places that already have enough so not to waste water or fertilizer. This normally leads to waste of water and excess spillage of fertilizer into the environment, on the produce or in water bodies.

As stated earlier, drones with thermal cameras can detect whether a field is well-watered or dry and needs optimization of water. Getting this information (data) can help farmers deal efficiently with irrigation thereby helping to avoid excessive use of water (Mazur, 2016).

They also help reduce excess fertilizer that may run off into nearby water bodies and cause harm to individuals. The use of drones and sensors limits leaching of nitrogen into the atmosphere and the environment. This helps reduce environmental risks and footprints of farming.

4.2.4 Employment Creation in Africa

Most African youth are not interested in engaging in agricultural production due to the risks involve in using existing old and inefficient methods of agricultural production. Transforming the sector and making it more attractive to individuals by employing UAV application can to some extent help with the creation of employment in Africa. This is because, the adoption of such

methods which result in efficient, effective and a more profitable production in agriculture would make the sector more attractive to the youth and other potential farmers.

More so, due to the linkages between the agricultural and the industrial sector, the outcome of the use of UAV in the agricultural sector would not only boost growth in the sector but also to some extent improve employment growth in the industrial sector. This is because the high productivity in the agricultural sector would increase the supply of raw materials by the agricultural sector to the industrial sector which in turn would enhance productivity in the (industrial) sector thereby increasing the level of employment creation of this sector.

Furthermore, producers of these forms of technology would gain more income as their products demand increases this would also make more people be employed in the production with the intension of producing more (Jenkins and Vasigh, 2013). Some people can also find themselves employment by providing hire-services of drone applications to agricultural produces and gain some income from it.

4.2.5 Increase income of UAVs suppliers and Improves economic growth of Africa

With the revolution of drone and sensor technology in agricultural establishments in Africa, a lot of people, as well as governments with interest in agriculture would be enlightened and begin to embrace their applications as they reap the benefits thereof. This would bring about a rise in their demand. The income and profits of the suppliers of this form of technology would increase as people demand more of their product. This in one way or the other would have a positive impact on economic growth of Africa through employment of local personnel, tax payment and corporate social responsibility of suppliers.

Furthermore, the economic growth of Africa would increase when agricultural productivity increases. This is because the impact would be extended to an increase in exports and reduction in imports of agricultural produce, increase in employment, raise standard of living and reduction in poverty.

All these benefits and a lot more could be derived from the application of drones, sensor technology and intelligent systems in commercial-scale agricultural establishments in Africa when there are well developed institutions and more realistic regulatory regimes that would ensure the safety and privacy of individuals across the continent by preventing users from applying in unauthorized areas.

5. Conclusion and Recommendations

From the analysis, we have seen that the application of drones, sensor technology and intelligent systems in agricultural establishments do not only come with their general benefits, but also have socio-economic benefits that could go a long way to help most countries and continents of which Africa is no exception. Some of such socio-economic benefits as discussed include reduction in poverty, environmental protection and water efficiency, employment creation, improvement in the balance of payment, increase in income of suppliers of UAVs and intelligent systems and improvement in economic growth of Africa.

Agricultural producers must embrace revolutionary strategies for producing food, increasing productivity and making sustainability a priority. Drones are part of the solution, along with closer collaboration between governments, technology leaders, and industry.

Governments in Africa that seeks to improve their agricultural sectors and encourage this smart way of agricultural production can to some extent subsidize the UAVs in order to make it more affordable for most people have access to.

More so, awareness of the application of these forms of technology in agricultural production should be created to ensure wider use of them by farmers across the continent.

However, for the full potential of the application of drones, sensor technology and intelligent systems to be realized, governments and policy makers must put in place some form of regulatory regimes that would ensure the safety and privacy of the citizens and other individuals in Africa. Regulations that would prevent UAVs users from flying over other people's lands and property without any authorization should be ensured. Also, there should be some form of regulations that would prevent or monitor their application in places that are considered residential with structures or unauthorized which could risk the safety of individuals.

More so, governments and policy makers in Africa can encourage the manufacturing of drones in their countries by partnering with manufacturers to develop industries that would manufacture them in the countries to help prevent import related problems.

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