

Eyes in the Sky for African Agriculture, Water Resources, and Urban Planning

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Exploring How Advances in Drone-Assisted Imaging and Mapping Services Can Bring New Income and Efficiency to Economic Development in East Africa



Using a Bird's-Eye View to Inform Ground Level Decisions

Economic development in sub-Saharan Africa faces multiple challenges, chief among them: increasing production and incomes on farms, preserving and managing freshwater resources, and getting a handle on the explosive growth underway in urban centers across the continent. There are a host of innovations available to help deal with these issues, but it can be difficult to assess which ones are worthy of investment.

One innovation that has received considerable attention in recent years is geospatial intelligence. This rapidly developing field involves using satellite and drone-assisted mapping technologies to guide investment decisions. In Africa, aerial mapping and measurement technologies hold immense potential to improve decision-making in every sector of the economy. The value of geo-intelligence services in the region is projected to triple from \$40 million in 2012 to \$150 million by 2020.

In particular, the use of drones—also referred to as “unmanned aerial vehicles,” or UAVs—in a variety of applications has expanded dramatically. Drones have certain advantages over satellite technology because they can fly below the clouds, while also offering 3D imaging options and the ability to carry light loads. In Africa, drones are already being deployed to deliver medical aid, combat poaching, and support wildlife conservation.

There is growing interest in expanding drone services to address other pressing issues in Africa. To learn more about the potential of this exciting and rapidly evolving technology, TechnoServe's Innovation in Outcome Measurement (IOM) initiative conducted a series of pilot projects in Uganda. These projects assessed the capacity of drone service providers to add value, efficiency, and accuracy to agriculture production, water management, and urban and rural development work.

Using Drones to Bring More Precision to Agriculture

Across Uganda, farmers struggle with low rates of agricultural productivity. Their yields—the amount produced per hectare or acre of land—are far below what farmers achieve in many other parts of the world. These low yields are due to a lack of inputs and mechanization, as well as insufficient training on advanced agriculture practices.

One of the more innovative approaches to farming gaining popularity around the world is called “precision agriculture.” It involves maximizing yields by using advanced technology and techniques to determine the precise amounts of water, fertilizer, pesticides and other inputs that should be applied on crops—and the best time for their application. Precision agriculture is proving to be particularly useful for improving seed multiplication, where anything compromising quality or quantity can have a significant negative impact on the sector.

Equator Seeds Limited is one of the leading seed multiplication companies in Uganda, with over 30,000 smallholder farmers—each cultivating seed on an average of 3.375 acres—serving as contractors or what are often referred to as “out-growers.” Currently, Equator Seeds is

multiplying over 50 seed varieties. Yet it lacks a reliable method for monitoring the production processes of its out-grower schemes as well as its own farms. TechnoServe’s IOM program partnered with Equator Seeds to evaluate the benefits of using private sector drone-assisted services to monitor production on contractor and company-owned farms. This partnership aimed to answer the following questions:

1. What are the benefits associated with drone-assisted imaging and mapping services provided to Equator Seeds and their out-grower farmers?
2. What are the costs associated with the use of drone technology in the agribusiness-level agricultural outcome measurement?
3. What is the potential of drone technology to help inform decisions by agribusinesses to expand operations and consequently increase profits?

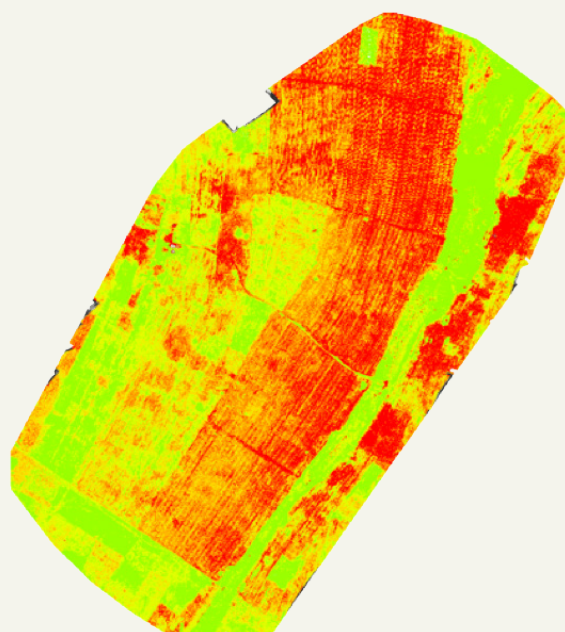


HOW DRONE TECHNOLOGY BENEFITS PRECISION AGRICULTURE

Drone technology offers unique tools for assessing the outcomes of farming strategies that could be very beneficial for agribusinesses. When equipped with high-tech devices such as multi-spectral sensors, drones can capture heat and other types of highly detailed imaging information—technical specialists sometimes call it “reflectance data”—that can be used to analyze plant health. They also can take advantage of advanced software to map out vast areas of land in considerable detail. The benefits of using drone services to drive precision agriculture include:

- **Farm Area Measurement and General Monitoring:** Drone technology can cover large areas of land and provide precise measurements of farm size—critical information for calculating input use and predicting yields. Drones can also provide a big picture view of the entire farm, which can reveal subtle changes that may not be apparent at ground level.
- **Yield Estimation:** Drones enable the capturing of aerial photography which, combined with satellite data, can help predict future yields based on current levels of field biomass, plant characteristics, or energy. Crop yield projections are vital for operational planning.
- **Crop Health Management:** Drone technology can assess the health of live vegetation, as well as its stress levels, providing an early warning about crop health issues. With this information, remedies can be provided, such as adjusting and more accurately estimating the amount of fertilizers and other inputs required to enhance yields.
- **Disease and Pest Identification:** Since flights can be conducted regularly, drone monitoring is ideal for identifying newly emerging pest and disease threats. This in effect, decreases blanket spraying of pesticides, reducing wastage.
- **Early Warning:** Early detection of pests and diseases can lead to interventions that can reduce crop losses. In the case of maize, this is expected to reduce losses by 10 to 24 percent. Early identification of areas lacking sufficient inputs can also eliminate crop losses linked to poor allocation of inputs like fertilizers, which leads to losses that are currently estimated at 50 percent for maize and 40 percent for beans and soy.

- Healthy Vegetation: no attention
- Healthy Vegetation: less attention needed
- Less Healthy Vegetation: attention needed, employ less resources
- Severe: Crop slow growth, soil exposed, employ more resources



Estimated Benefits of Drone Technology for Equator Seeds and Producer Farms

Through flights and data analysis, IOM experts assessed the benefits of drone services for Equator Seeds and found that they provided substantial benefits to both the company and contractor farms serving as producers or out-growers for the company. Farmers' profits are projected to increase by over \$2,000 per farm within a year due to better support offered by the agribusiness using insights from drone flights. The assessment culminated in the development of a six-month action plan to implement the adoption of drone technology. Implementation is expected to start in 2018 and target 270 farmers. These 270 pilot farmers are expected to gain a total of \$478,000 in annual profits, while Equator Seeds will gain profits of \$4.2 million, a return on investment (ROI) of \$14 for each \$1 of program investment.

The company is now planning to roll out drone

and satellite monitoring of all its operations, at an estimated startup cost of \$200,000. In the first year alone, IOM has estimated that its outgrower farmers will gain over \$31 million with Equator Seeds gaining \$137 million. This represents an ROI of \$495 for every \$1 of Equator Seeds investment and over \$423 for each \$1 of program investment.

Demand for quality seeds is rising rapidly in Uganda, but production levels at Equator Seeds have been limited by the company's inability to monitor seed production. The efficiencies provided by drone services will allow Equator Seeds to expand its production network, creating more income opportunities for Ugandan farmers and steadily higher revenues for the company. Its network of farmers is projected to grow from 30,000 to 43,000 over the next five years, with farm profits projected to reach over \$280 million.

Estimated Benefits in the First Year from Using Drone Services to Monitor Seed Production

\$31 million

ADDITIONAL PROFITS FOR EQUATOR FARMERS: Due to a projected 100 percent increase in yield and 60 percent reduction in pesticide use (caused by the elimination of blanket pesticide application). For individual farms, returns are projected to increase by over \$1,800 for maize seed production, \$1,800 for beans, and \$1,500 for soy (+ \$500/acre on average).

\$140 million

ADDITIONAL EARNINGS FOR EQUATOR SEEDS: Using drones to monitor farms generated more seed and hence more revenue, and while costs of fertilizers and monitoring went up, costs of pesticide application dropped.

\$423 per \$1 invested

RETURN ON INVESTMENT: \$423 per \$1 invested by the program in year one alone. Taking into account the anticipated expansion of the Equator Seeds operations, the five year ROI is expected to be over \$1,900 for each \$1 invested by the IOM program.*

\$630 million/150 million

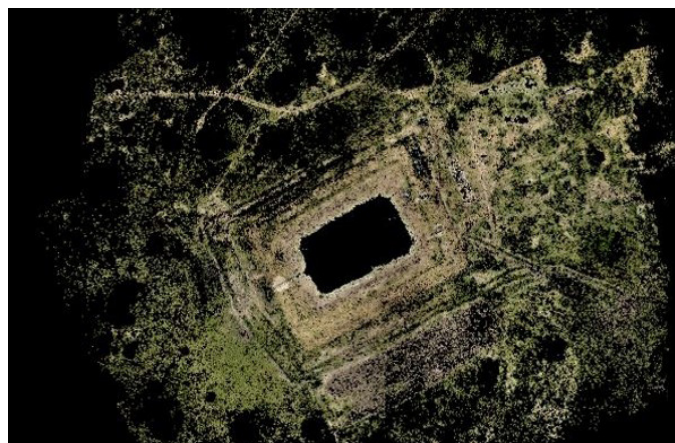
PROJECTED FUTURE EARNINGS: \$630 million for Equator Seeds, \$150 million for Equator Seeds farmers over the next five years. Demand for seed is surging, yet Equator Seeds has been constrained in its ability to increase production due to the need to monitor farms—a constraint that can be eliminated by drone technology.

*To date, IOM has invested a total of \$421,000 in the Equator Seeds pilot, including \$60,000 in contributions from key partners.

Using Drone Assisted-Mapping to Improve Freshwater Storage

In rural Uganda, rapid population growth, drought, and pollution are increasing pressure on freshwater resources vital to sustaining communities and livestock. Investment in water storage by the government of Uganda is therefore essential for agricultural and other economic development projects.

Over the last few years, 150 dams and valley tanks (small reservoirs created by building a dam across a natural valley) have been constructed across the country. The government of Uganda is now planning to build an additional 850 dams. IOM partnered with Earth Consult, a surveying and mapping firm working with Uganda's Ministry of Water and Environment, to evaluate the benefits of using drones to map out valley tanks and the



volume of the dams that created them. The goal was to provide the Ministry with valley selection and dam capacity estimations.

Benefits of Using Drones in Valley Tank Mapping

IOM's assessments found that drones delivered considerable cost savings and other benefits to the Ministry's water management program. In addition to better policy responses by government ministries, these benefits include:

➤ **Labor savings:** Drones require fewer staff than alternative approaches, such as manually recording GPS coordinates and gathering and processing satellite imagery. By using drones to map 14 valley dams, Earth Consult is expecting labor savings of over \$30,000.

➤ **Time savings:** Using conventional mapping methods, it takes 11 days to map out a valley tank. With drone technology, the same mapping can be done in three days (a 73 percent time saving).

The table below highlights the resources saved by using drones for mapping out valley tanks:

VARIABLE	UNIT	MINISTRY OF WATER CONSULTANTS	DRONE SERVICES	RESOURCE SAVINGS
Number of people required to map one valley tank	#	4	2	
Total number of days required to map one valley tank	#	11	1	
Person days required to map one valley tank	#	44	2	
Labor savings from mapping one valley tank	US\$	2,495	113	2,381
Labor Savings when mapping 14 valley tanks	US\$			33,300
Labor Savings when mapping 850 valley tanks	US\$			2,000,000



Using Drones to Improve Urban Planning

With accelerating urbanization, urban infrastructure improvements still lag behind the overall pace of development. As a result, the Government of Uganda is rapidly investing in large-scale infrastructure projects and looking for new sources of high-quality data to inform its decision-making.

Metrisys is a company that offers products and services in geomatics, infrastructure software, measurement automation, and environmental marketing. With the help of TechnoServe's IOM program, Metrisys is using drone technology to map out urban dwellings to produce 3D imagery of urban settlements and urban and peri-urban

road networks for the Kampala City Council Authority. Insights from this project can be used to analyze population growth, plan construction of new roads and electrical grids, as well as help make city buildings safer. Drone monitoring capabilities can identify new construction zones and allow the Government to ensure that proper safety inspections have been conducted.

The table below provides examples of resource savings generated by drone services for the Kampala City Council Authority's planning work. The results clearly demonstrate that drone imaging technology is superior to existing planning tools on all fronts: cost, labor, and time.

VARIABLE/PARAMETER	UNIT	TRADITIONAL URBAN PLANNING METHODS - ESTIMATES	USE OF DRONE MAPPING
Cost per square Kilometer (km ²)	US\$/km ²	57,989	11,226
Number of days worked/km ²	#	27	4
Number of persons per day	#	72	2
Person days per km ²	#	1,932	8
Person days to map Kampala	#	340,108	1,408
Cost of labor required to map Kampala (176 km ²)	US\$	19,300,000	80,000
Cost savings on labor alone	US\$	19,200,000	

Putting Aerial Technologies to Work for African Economies

Although drone technology services are growing rapidly in East Africa, their potential remains largely untapped. These pilot projects demonstrate that drones have enormous potential to provide a cheaper, faster, and better way of conducting measurement and monitoring work over conventional approaches. The pilot projects produced consistent results. Whether it was to improve seed production, build dams and valley tanks, or make complex urban planning decisions, in all cases the drone services were superior. Evidence of their capacity to enhance incomes and production in agriculture was particularly evident, but potential improvements for public works and public planning projects appear to be promising as well.

Generating sustainable economic growth that creates new opportunities in sub-Saharan Africa requires confronting fundamental challenges in food production, water resource management, and urban planning. It is critical to continue exploring the potential of new innovations



like drone-assisted monitoring and mapping services to provide insights that can overcome barriers to progress in all of these areas. Rigorous assessments, like those performed by TechnoServe to evaluate drone technology, can provide the evidence required by public and private sector interests to allocate resources for innovations that are most likely to deliver immediate and substantial benefits.



It is critical to continue exploring the potential of new innovations like drone-assisted monitoring and mapping services to provide insights that can overcome barriers to progress in all of these areas.

The Way Forward

Equator Seeds has planned to adopt the use of UAV. Rolling out the technology gradually, the agribusiness will be able to enroll over 43,000 farmers in the outgrower scheme in five years. This opportunity poses new challenges as to how much the UAVs can be institutionalized without pulling the agribusiness staff and operations away from its core business—seed multiplication.

The adoption of the technology will require that decisions be made to step up monitoring operations, necessitating some operational changes and capacity development. Equator Seeds will need to build specialized staff capacity to fly the UAV and analyze drone images; it will also need additional human resources on the ground to do ground truthing and inform action immediately.

The project partnered with Geogeko and Automated Systems Research (ASR), two dynamic geospatial firms, to test the viability and value of deploying and utilizing UAVs to survey agricultural areas and analyze the results to enhance agricultural decision-making. While ASR

was involved in conducting some of the flights, Geogeko participated in analysis of Equator Seeds data to develop a business case for the provision of UAV services, including making feasible cost estimates.

Based on Geogeko's analysis, scaling up these efforts—which would involve analysis of farm-level satellite imagery; creation of algorithms for crop health and pest identification; UAV survey and repeat flights every two months; and ground truthing, analysis, and monthly reports—would cost an estimated at \$140,000 annually. Regular meetings would be required to discuss flight results and incorporate decisions in the client's day-to-day monitoring operations.

Continued testing and analysis involving other businesses is needed to develop additional use case scenarios for different sectors. A growing body of evidence on this high-potential technology can guide private and public sector actors on adopting the right business models to address needs and maximize profits.

Scaling Up: Projected Profits for Farmers and Agribusiness



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