Innovation in Outcome Measurement

EVIDENCE DRIVING TRANSFORMATION OF SMALLHOLDER AGRICULTURE

TECHNOSERVE
BUSINESS SOLUTIONS TO POVERTY

COVER: FLICKR/GEORGINA SMITH (CIAT)

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PART I

INTRODUCTION

In December of 2015, the Bill & Melinda Gates Foundation joined forces with TechnoServe to launch the groundbreaking Innovation in Outcome Measurement (IOM) program. The two-year, US$1.6 million initiative set out to develop more precise, cost-effective tools and methodologies that could measure, in considerable detail, the outcomes of a wide assortment of agriculture interventions. The goal: cheaper, better, faster ways of collecting key agricultural data.

IOM spent the last two years identifying and testing, in real-world settings, new measurement approaches, and simultaneously using them to find innovations capable of transforming smallholder agriculture. In the process, it has been able to reveal—and frequently overcome—barriers to wider adoption while identifying potentially promising paths to rapid scale-up.

IOM's work has provided an important reminder that innovation in any sector requires the efficient conversion of compelling ideas and research findings into commercially viable products and services. How does that occur in agriculture in Africa?

In developed economies like those of Europe and the United States, there are well-established systems where venture capitalists, business incubators and other entrepreneurial players routinely collaborate with university and government-supported researchers to test new ideas. Companies like Google and others in Silicon Valley, the biotechnology industry, and new aerospace companies like Space X, all are rooted in government and academic research partnerships with industry that have translated innovations into commercially viable and commercially sustainable applications.

But these kinds of collaborative, translational partnerships are poorly developed or non-existent in most economies in sub-Saharan Africa, especially in the agriculture sector. As a result, there is a very limited stream of agriculture innovations developed by African researchers that are reaching African farmers. For example, a promising seed coating technology developed by Kenyan researchers in the 1980s has yet to make it to market even as similar innovations developed abroad are now being commercialized in the region (see sidebar). But the problem with depending on agriculture innovations developed outside of Africa is that they may or may not be a good fit for Africa's food producers.

For example, there is no model in the United States or Europe for delivering commercial veterinary services to remote pastoralist herders who travel with their animals across long distances, or for creating product quality standards and meat traceability regimes for this unique and neglected class of livestock keepers (see page 9).

PHOTO: FLICKR/NEIL PALMER (CIAT)

Similarly, there is no roadmap for efficiently organizing thousands of poor smallholder farmers—most of whom have access to an acre or two of land—into a profitable commercial venture that can consistently deliver reliable quantities of high-quality and highly perishable produce to lucrative export markets (see page 12).

If there were, they would need to be tested and refined via either company-funded product and service development departments or via a government funded research entity, such as a land-grant agriculture-focused university.

But in all these instances, and many more, TechnoServe's Innovation in Outcome Measurement (IOM) project is uniquely positioned to be that catalytic translational actor so often missing in African agriculture. IOM works with multiple partners from the public and private sectors to design and pilot projects that can reliably assess the commercial potential of a wide range of agriculture innovations. It also tests the commercial viability of those innovations via highly rigorous assessments. Our work produces robust hard data about returns on investments and reveals valuable lessons that can help fuel rapid scale-up.

Ultimately, while IOM began as an initiative for assessing and measuring outcomes of agriculture ventures, it has come to provide much more. It has been able to deploy the resources and expertise required to test the commercial viability of agriculture-related innovations in ways that ensure they are addressing uniquely African agriculture challenges and opportunities.

IOM at Work: Measuring to Make a Difference

Many economists believe that in sub-Saharan Africa, the best bet for rapidly reducing poverty and generating inclusive, long-term growth is by developing an agriculture sector where millions of smallholder farmers can transition from subsistence to income-earning crop and livestock production.

But without reliable methods for identifying commercially viable agriculture innovations and piloting their potential in real-world ventures, widespread scale-up and adoption is unlikely to happen. This fact is particularly true in an agriculture sector dominated by poor farmers and small- to medium-sized agribusiness enterprises that lack a basic network of support systems common in many developed countries. As a result, they are ill-equipped to shoulder all the risk of identifying and adopting new ways of producing and marketing agriculture products compared to their larger and more sophisticated counterparts in the West.

Over the last two years, IOM has developed an effective, methodical, iterative approach for identifying and assessing agriculture interventions intended to benefit smallholder farmers and livestock producers. As a result, it has been able to show how innovations as varied as mobile veterinary services, drone-assisted crop surveillance, and vertically integrated crop production and processing operations can be piloted and primed for expansion. The approach involves:

TRANSLATING INNOVATIONS INTO COMMERCIAL PRODUCTS

1

Innovation Selection

Identifying promising innovations with high potential for commercial success through a methodical, objective process;

2

Participatory Pilot Design

Co-designing pilot projects together with researchers, technical experts and—most critically—potential investors, to ensure the pilot results can guide concrete decisions such as whether, when and how much to invest;

3

Business Case Modeling

Developing analytical tools and models to translate lessons learned from the pilots into clear and actionable business profit-and-loss terms that form the basis of business cases for investment in the innovation;

4

Business Case Development

Documenting the development context of the innovation, including barriers, limits, challenges and opportunities associated with innovation uptake; and

5

Dissemination to Investors

Disseminating the results widely to potential investors, adopters and stakeholders who can participate in taking the innovation scale.

Over the last two years, IOM experts have been applying this process to assessing the potential of:

- Livestock health and product quality management;
- Application of drone-assisted mapping and geospatial monitoring services;
- Unlocking commercial potential of smallholder agriculture by using information and communications technology (ICT) to manage value chains; and
- Precision soil and plant measurement for evidence-based agronomy.

The following sections provide brief summaries of individual projects, detailing the agriculture innovations piloted, examples of measurement innovations employed to gauge their success, the key results posted to date, and the lessons learned that have implications for their potential scale-up. They are followed by a section that offers a more in-depth and technical summation of IOM's rigorous approach for developing economic models and business plans that provide a clear picture of the profitability and commercial viability of agriculture-oriented development interventions.

We then conclude with a brief summary of broader lessons that have emerged from IOM's work, which could be applicable to any effort to take potentially transformative innovations and use them to boost production and income on smallholder farms.

PART 2

PROGRAM SUMMARIES

SECTION 1

Livestock Health and Product Quality Management

OVERVIEW OF ISSUE

For most pastoralists across sub-Saharan Africa, livestock are consistently their most valuable assets. They are sources of food (meat, milk, blood), they act as savings accounts, play various social roles (dowry, fines) and provide valuable manure for crop farmers.

Livestock keepers in Africa face many constraints when it comes to realizing the potential of their animals to provide income for their families. They include a lack of protection from diseases that routinely kill and weaken animals and a dearth of commercial opportunities to earn income from their work.

Both challenges are especially pronounced for poor pastoralist herders who graze their animals across the vast drylands of East Africa. Their remote and often nomadic life makes it difficult for them to coordinate access to veterinary and other livestock services. As a result, private veterinary service providers have been reluctant to proactively seek out pastoralists as customers. In addition, these herders also find themselves excluded from modern livestock markets where quality assurance is a key requirement for entry.

The two challenges often work in tandem to create a negative feedback loop: sick animals have little or no market value. But without market opportunities, herders lack the resources to attract commercial veterinary services that could keep their animals healthy. Therefore, donors and governments need to shift their support to where they add value (i.e., focusing on ways in which they can help transform markets to maximize social benefits and minimize market distortion from subsidies). This will entail working with the private sector to integrate a profit motive and practices that deliver sustainable commercial services.

Over the last two years, IOM has served as a vital partner by contributing to the design and assessment of commercially sustainable approaches of delivering veterinary services to pastoralist communities, and developing quality assurance systems and capabilities that could open up new income opportunities for livestock keepers.

1.1

Going Mobile with Veterinary Services

To improve livestock health, IOM worked with a strong team of partners to set up pilots to test innovative ways of delivering private veterinary services to pastoralist herders. Those partners include ILRI and Kenya Markets Trust (KMT), both implementing interventions in arid and semi-arid lands aimed at strengthening the performance of livestock markets to function better for producers, suppliers and consumers. The partnership was based on shared goals and their understanding of the local landscape and existing infrastructure (ongoing projects, as well as public and private sector networks), and potential scale-up of results.

AGRICULTURE INNOVATIONS TESTED

The pilots targeted a total of 2,500 farmers with one of three different approaches for expanding access to veterinary services:

- Sending commercial providers on a weekly circuit to pastoralist communities and gathering places, usually with government-employed animal health workers;
- Bundling commercial products with services provided in government or NGO-sponsored animal health campaigns; and
- Setting up a network of micro-franchises for veterinary products housed inside small local retail shops.

The goal was to evaluate whether these delivery methods are sustainable and profitable for commercial veterinarians and create value for pastoralists.

MEASUREMENT INNOVATIONS TESTED

- Tools for capturing the variability in economic returns from the use of mobile veterinary services by each of six unique types of livestock keepers across three distinct rangeland regions of Northern Kenya; and
- Models that commercial vets can use to evaluate the risks and returns of mobile delivery.

KEY RESULTS

Preliminary field estimates have found that combining commercial and public livestock veterinary services via a mobile delivery system resulted in a 14 percent drop in animal sickness and death worth over US$7,400 annually for each pastoralist "boma."[1] Profits for the three commercial agrovets are estimated to rise by US$360,000/year for the limited pilot regions alone. This new mobile veterinary industry is projected to gross over US$300 million over three years.

[1] Large, multi-family pastoralist household owning 200-350 head of livestock.

LESSONS LEARNED

RELATIONSHIPS

Private service providers who accompany government vaccination campaigns to provide additional services forged a good working relationship with public sector workers. Service providers also built strong relationships with pastoralists that extended beyond just the product or service. Their technical expertise enhanced the capacity of pastoralists in animal health care and disease reporting, services typically available only in urban areas. These relationships earned commercial service providers the goodwill of both public-sector workers and pastoralists, who were convinced that commercial providers add significant value to the existing system of providing veterinary care.

BARRIERS/RISKS

Free veterinary services offered by either government or NGOs continue to discourage private sector providers, even though these free services are intermittent and do not cover the full array of animal health needs. There is a need to review policies and programs to encourage a system where public and private sector services are complementary, rather than competitive.

DONOR ROLE

The public sector will continue to play a significant role in the delivery of animal health services in the arid and semi-arid lands of East Africa—but with a focus on a narrow range of diseases. Donors have the opportunity to support strategies that provide opportunities for private sector service providers to address animal health challenges not covered by public sector programs. One strategy is to support entrepreneurial commercial veterinarians who are willing to make regular visits to areas where pastoralists often congregate with their animals. In particular, donors could support young graduates of veterinary health programs who lack start-up funding but see a business opportunity in serving rural livestock keepers.

1.2

Tracing Livestock Quality, Finding Profits

The demand from export and local niche markets for traceability is becoming more and more apparent, especially for local meat processors to continue competing for high-value markets such as the United Arab Emirates and local high-end supermarket retail chains. Typically, retailers like Tuskys Supermarket and meat processors, such as Neema Abattoir and Choice Meats, are driving this change to serve a customer base with changing attitudes, affluence and expectations. It is the consumers who keep the sector in business.

IOM worked with Kenya Markets Trust, the Kenya Commercial Bank Foundation, the International Livestock Research Institute and the Regional Pastoral Livelihoods Resilience Programme to assess the potential value of establishing a modern, end-to-end livestock quality and traceability system that could open new market opportunities for cattle raised by Kenya's pastoralist herders.

Meat processors have seen their market opportunities limited by a lack of reliable, tamper-proof animal identification and tracking systems for ensuring the quality and safety of livestock products as they move from pastures to buyers, abattoirs (slaughter houses), butchers, retailers and consumers. For example, buyers in the United Arab Emirates are serving consumers concerned about hormones and drug residues in meats, along with disease outbreaks and zoonotic infections in livestock that may affect human health.

AGRICULTURE INNOVATION

IOM set out to analyze potential benefits from a system that includes live animal tracking via radio frequency identification tags/implants that can be attached to a cow's ear and encoded with data verifying the animal's origin and vaccination regimen. The system also features: regular disease surveillance and veterinary services; finishing lots for fattening up animals prior to slaughter; and a method for tracking livestock products with bar and QR codes as they move from abattoirs to butcheries, wholesale buyers and end-consumers.

MEASUREMENT INNOVATION

IOM developed an economic model that reveals potential returns to pastoralists, livestock veterinarians, feedlot operators, abattoirs, butchers and the public sector from investments in a modern livestock traceability system for high-value meat products. A key aspect of the measurement model is that it isolates each player in the system and considers the specific benefits that would accrue to each of them.

KEY RESULTS

A comprehensive livestock traceability system for Kenyan pastoralists would add about US$0.17 per kilo to the cost of raising, finishing and slaughtering a cow. But it would generate a return of about US$4 per kilo (over US$400 per cow), with the biggest benefits going to pastoralists and slaughter houses—who would also bear the bulk of the costs. Pastoralists would enjoy increased profits of US$397 per cow, and primary meat processors (butchers) would see increased profits of US$286 per animal. Also, adopting refrigeration systems has the potential to reduce waste via spoilage and thus cut costs by over 25 percent, far greater than the small cost of the technology itself—this could potentially transform and modernize the Kenyan meat industry forever.

LESSONS LEARNED

RELATIONSHIPS

More research is needed to assess the benefits that are accruing to different actors at various points in this particular value chain for livestock products. But there is evidence that the fundamental aspects of a quality assurance program—the capacity to address animal health, livestock identification, hazard analysis at critical control points (HACCP) and "finishing" in feed lots—have been established and are ready to move forward in concert. It is now essential for producers and other industry stakeholders to work together to define the level of traceability they can sustainably achieve. The same collaborative approach implemented by IOM for the pilot project can be valuable in scaling up a traceability network.

BARRIERS/RISKS

Farm-to-fork traceability is expensive. There needs to be convincing evidence of consumer willingness to pay a premium for quality assurance. IOM was surprised to discover that high-end retailers were not operating within a traceability system. Also, pastoralists seemed unconvinced that potential returns were sufficient to warrant investing in a livestock identification system. Finally, current approaches to assessing the feasibility of tracing systems for livestock and livestock products tend to focus on one aspect of the system, such as the ID tags or access to finance. But it's important to look at the entire system.

DONOR ROLE

There is an opportunity to support a traceability systems partnership with Neema and Choice Meat Abattoirs. But a strong business case for traceability driven by major industry players needs to be developed, a role which private actors may not yet be ready to take up.

SECTION 2

Drone-assisted Mapping and Geospatial Monitoring Services

OVERVIEW OF ISSUE

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 that's pushing out into farmlands. 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 imaging and 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 US$40 million in 2012 to US$150 million by 2020. To learn more about the potential of the exciting and rapidly evolving applications of geospatial technology, IOM has been a partner in a series of pilot projects in Uganda. One projuect focused on using drones and satellite-based imaging to boost profits in seed multiplication. The other is evaluating their potential to assist water management and urban planning.

Currently, the relatively small size of most African farms and the skill level required to implement a drone-based farm monitoring program restricts current clients to large farms or to businesses that contract with multiple smallholders to produce commodities in what are known as "out-grower" schemes. In addition private sector geospatial firms in the region have been more focused on chasing government contracts for their services than in developing new products and services targeting potential clients in agriculture. That's why the IOM stepped in with its program: to demonstrate cost-effective applications of what could be a game-changing technology for the African agriculture sector.

Three projects are explored individually below, along with a series of lessons learned that are applicable to all.

2.1

Multiplying Products and Profits at Equator Seeds

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—working on contract as producers or "out-growers," as they are often called.

Yet Equator Seeds' growth has been stymied by the absence of a reliable method for monitoring the production, both at its own farms and those belonging to contractors.

AGRICULTURE INNOVATION

The IOM program has partnered with Equator Seeds to evaluate the benefits of using private-sector drone-assisted imaging and mapping services to monitor production on contractor and company-owned farms. Specifically, Equator Seeds needs regular insights about the precise amounts of water, fertilizer, pesticides and other inputs that should be applied—and the best time for their application.

> 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 call it "reflectance data"—that can be used to analyze plant health. These insights can lead to much more precise uses of fertilizers, pesticides and other inputs. Drone technology can also be coupled with advanced software to map out vast areas of land in considerable detail.

MEASUREMENT INNOVATION

Developing the methodology to measure the cost-effectiveness of commercial drone imaging to inform precision fertilizer application and precision pest management in maize, bean and soy seed production in two regions of East Africa.

BIG PLANS ON THE GROUND FOR FARMERS' NEW EYES IN THE SKIES

Drones' flight and data analysis were conducted and results shared with Equator Seeds. This culminated in the development of an action plan (June-Dec 2018) to implement a drone-assisted remote farm monitoring system. This implementation started in January 2018 and will end in June 2018, targeting 270 farmers in the first cropping season.

With the improved farm monitoring capacity, Equator Seeds plans to expand their operations to better meet their clients' enormous seed needs, and enroll more farmers into their out-grower scheme.

The plan includes physical verification of drone imagery results to identify areas that need attention. Fertilizer and pesticide application recommendations will be derived from drone imagery data and machine calibrations, with the goal of aligning applications with specific soil nutrition and pest management needs.

In the subsequent seasons, expanding the use of drones will be accompanied by the establishment of a geospatial unit, a department within Equator Seeds to work closely with agronomists and its production department to process and disseminate spatial information and advise the company on actions to take during production. It is expected that Equator Seeds will enlist a service provider to provide complementary remote sensing services to cover larger areas in the districts where they operate. This will give a larger, general view of the out-grower scheme with drone flights conducting specific data collection at the most critical times of the crop life cycle.

KEY RESULTS

The 270 pilot farmers are expected to gain a total of US$478,000 in annual profits, while Equator Seeds gains profits of US$4.2 million, a return on investment of US$14 for each US$1 of program investment. Farmers' profits are projected to increase by over US$1,700 per farm within a year due to better pest management and fertilizer application using insights from drone flights. Equator Seeds is now planning to roll out drone and satellite monitoring of all their operations, at an estimated startup cost of US$150,000. In the first year alone, IOM has estimated that their contractor farmers will gain over US$31 million, with Equator Seeds gaining US$137 million. This represents a return on investment of US$495 for every US$1 of Equator Seeds investment and US$423 for each US$1 of program investment.

2.2

Managing Water Resources and Urban Planning in Uganda

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

Meanwhile, as with other African countries, rapid urbanization is creating demand for modern city planning capabilities to create a more orderly expansion of residential and commercial areas and design transportation infrastructure to serve them.

AGRICULTURE INNOVATION

IOM set out to evaluate how drone-assisted mapping services can inform decision-making in both areas—particularly in citing the location of new reservoirs and developing 3D imagery of urban settlements and urban and peri-urban road networks in Kampala City.

For water resource management, 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 small reservoirs (locally known as "valley tanks") and the volume of water they can hold. The goal was to provide the ministry with information on selected valley dams to demonstrate how drones can optimize their location by providing an estimate of appropriate size, along with insights on the orientation of water catchments and basins and elevation levels. This information eventually can reveal tank capacity and how that volume compares to the water demands of local livestock, crops and people.

MEASUREMENT INNOVATION

- Assessing the value of using drone-assisted 3D imaging capabilities to conduct rapid remote mapping of river valleys and generate precise analysis of the volume held in each water catchment
- Using drones to quickly produce detailed maps of urban settlements and area road networks

KEY RESULTS

Using drones to map water resources generated huge savings compared to traditional manual methods in terms of time (one day compared to 11 days for one valley tank), labor (two person-days compared to 44 person-days for one valley tank) and cost (US$33,300 in savings). Using drones to map out plans for the 850 tanks on the drawing board offers US$2 million in saving. Similarly, using drones for 3D mapping of urban areas generated over 99.5 percent in cost savings—savings of over US$19.2 million from mapping the city of Kampala alone.

FINDINGS FROM IOM'S STUDY OF THE GEOSPATIAL INDUSTRY

In 2017, IOM commissioned a broad study of the geospatial industry, which revealed several areas:

- Reliance on Government Tenders: Larger geospatial firms rely heavily on government tenders for their revenues. This intensive process leads to the neglect of other potential market segments, as well as the neglect of marketing and branding functions critical to competing in the "normal" market.

- Two business models: Younger geospatial companies are more problem-centric and focus on creating innovative products to solve practical problems, whereas traditional firms focus more on providing access to software, hardware and training—a set of services which is likely to diminish in market importance as consumers become more demanding and competition in this space rises.

- Lack of Industry Communication: There appears to be a lack of interest in setting up an industry organization or association, despite the huge potential for industry-wide growth.

- Gaps in client-focused product development and messaging: There is a major gap in the capacity of geospatial firms to target their product/service offering to meet the need of their clients, and exploit the marketing benefit of messaging around those products and services.

Overall, public sector players, including the statistics agencies, aviation authorities, and local and county governments, will play a pivotal role in creating an enabling environment for accelerating adoption of drone technology.

LESSONS LEARNED (GEOSPATIAL MAPPING SERVICES)

RELATIONSHIPS

For efficient capacity utilization, private sector actors need to develop a business case for using drones beyond just the agriculture sector. Doing so requires reaching out to potential clients to demonstrate applications that generate cost savings and new levels of efficiency. Companies also need to engage public sector actors—including civil aviation authorities—to discuss policy actions related to licensing drone operators, flying restrictions, and sharing and using aerial data, which can involve security and legal concerns. Tanzania and Uganda have granted permissions to operate drones and Kenya is working on a legal framework.

LESSONS LEARNED (GEOSPATIAL MAPPING SERVICES), CONTINUED

BARRIERS/RISKS

There is no framework in place in East Africa for regulating commercial applications of drone technology. For example, officials are still wrestling with security concerns related to drones, such as their potential use in terror attacks or the risk of collisions with conventional aircraft. Meanwhile, the geo-fencing and collision avoidance technologies that would make flying agricultural drones safer and make regulators feel more comfortable with larger numbers of drones taking to the skies are only available in few drone types, not necessarily those used in agriculture.

There remain multiple barriers around the technological capacity of the drones themselves, and in gaining capabilities required to interpret the data they generate. There is also a gap among geospatial service providers in understanding the true value proposition of using drones. And for agribusiness applications, perceived high cost of drone services has slowed adoption, along with reluctance to make the operational changes required to convert to remote monitoring methods.

That said, there are legitimate questions about how adopting unmanned aerial vehicles (UAVs) may distract companies like Equator Seeds from their core mission, which is to deliver a wider menu of high-quality seeds to African farmers. For example, Equator Seeds would need to set up an assortment of internal processes for initiating and monitoring imagery of their agriculture lands. Such administrative and logistical changes can be time-consuming and resource-intensive.

DONOR ROLE

Cost-sharing between donors and private sector partners can accelerate the development of commercial drone services in East Africa by reducing the financial risks of launching a business based on a new and rapidly developing technology. Government agencies can also play a role by creating an enabling environment for developing applications for drone technology and by considering the use of drones to inform public decision around utilities and other infrastructure projects. There also was interest in the value of the economic models and business plans developed by the IOM team (see additional insert entitled Economic Models and Business Plans) as a way to help stimulate more commercial ventures involving geospatial mapping services.

SECTION 3

Using ICT to Unlock Commercial Potential of Smallholder Agriculture

OVERVIEW OF ISSUE

A key challenge in the effort to create income opportunities for smallholder farmers involves how to successfully connect small producers to commercial markets for agriculture products. IOM has been evaluating different ways that smallholder farmers and other agribusinesses can use advanced information and communications technology (ICT) in what economists call the agriculture value chain. One project assesses the use of ICT advances to make commodity exchanges more accessible to smallholder farmers. Another is developing a potentially scalable model in which ICT applications are playing a key role in managing a large network of smallholder farmers who are growing produce for export to the United States.

3.1

Creating a Digital Commodity Exchange

In rural Kenya, agricultural commodities are mostly marketed via traditional or informal agricultural trading networks, where trading is often a hazardous and costly affair. To find each other, buyers and sellers often travel great distances that require significant investments of time and money. Farmers have the additional problem of limited access to information on market prices and quality requirements, a blind spot many traders exploit with take-it-or-leave-it offers. Finally, both buyers and sellers have very limited legal recourse should one party violate the terms of a contract through default or cheating.

These dysfunctions create poorly performing agriculture markets and diminish farmer incentives to make significant investments to improve production, storage and on-farm processing. A functioning agriculture commodity exchange can help solve problems for all market actors. For farmers, exchanges provide transparency in pricing and quality standards, while frequently offering options for storage. For traders, the exchange shifts incentives away from trying to pay the lowest price possible to individual farmers toward aggregating large amounts of commodities to supply big purchasing contracts.

AGRICULTURE INNOVATION

IOM partnered with Akili Holdings of Kenya, a business focused on creating commercial opportunities for smallholder farmers, to evaluate the feasibility of establishing a commodity exchange in Kenya's Kirinyaga and Embu counties. The goal was to understand if key components of a commodity exchange existed in the areas, chiefly: a sufficient amount of surplus tradable crop production on local farms, a large cadre of local buyers, or "middle men" seeking to purchase farm commodities, and significant capacity for storing farm commodities, as well as auxiliary services necessary for a commodity exchange to function.

MEASUREMENT INNOVATION

IOM developed a system for measuring two models of commodity exchanges, one focused on warehousing and trading in dry cereal crops, the other on selling perishable produce via auctions. A key feature of both exchanges was an open ICT system that would provide farmers access to data revealing, in real-time, current trades on the exchange and prices being paid for different farm commodities.

KEY RESULTS

The evaluation found that creating a viable local exchange where farmers could sell surplus would induce a 30 percent drop in post-harvest losses and a US$3.35 million increase in annual profits for local farmers in the two counties of Embu and Kirinyaga. And attracting local farmers would also bring local market traders, who would pay nominal fees to help cover exchange operating costs.

LESSONS LEARNED

RELATIONSHIPS

The study advocates for the establishment of a commodity exchange to serve both counties, as well as other neighboring counties. The actual situation in the two counties in terms of market institutions and services required of a commodity exchange is very good and can support the existence of the enterprise. Further, there are models already working in Africa to benchmark, providing the opportunity for learning and tailoring the innovation to local conditions.

BARRIERS/RISKS

A key issue observed was a dearth of cash crops, typically an income driver for a commodity exchange. There also needs to be further investigation of the trading potential and preparedness of various market participants to operate within a commodity exchange environment.

DONOR ROLE

Appropriate donor support for commodity exchange would include: (a) analytical support for the exchange, including business planning and assistance in selecting firms or consortia to run the exchange and set up the ICT infrastructure; (b) Buying down the investment risk by reducing the cost of the initial investment, possibly by absorbing some of the initial setup costs such as ICT infrastructure; and (c) Communication to all actors of the roles and requirements of each set of market actors in the exchange process, potentially including training, capacity building, and support for government regulation and certification processes related to the exchange.

3.2

Spinach: Good for the Body, Good for Business

IOM is also working with Kenya's Akili Holdings to support and evaluate Akili's efforts to create a business relationship with smallholder farmers and fill a lucrative contract with an American company seeking a large, steady supply of dried spinach.

AGRICULTURE INNOVATION

Akili set out to build a reliable network of suppliers by addressing a variety of risks. It offered farmers stable pricing, affordable crop insurance, high-quality inputs, advice on production practices, and access to financing. Akili also has established a processing facility in close proximity to local farmers for drying and packing the produce. In addition, Akili established systems for ensuring its spinach was compliant with US food safety standards, a barrier that has tripped up other efforts to link African farmers to US and European markets.

Akili also organizes farmers into small "accountability groups" that shared responsibility for things like input credits. These groups helped to stem organizational breakdowns, such as farmers ignoring their contract and selling their harvest to a different buyer, which can erode the commercial potential of contract farming arrangements.

MEASUREMENT INNOVATIONS

- Using ICT platforms to track farmer demographic, production, input use and credit data, while also using ICT applications to manage inventory, payments, bar-coded product tracking and other operations
- Using low-cost soil measurement tools to guide farm-level soil fertility management
- Creating a model that can quantify the economic value of Akili's various efforts to minimize farmer risks

KEY RESULTS

Annual incremental earnings were estimated at US$265–$5562 per farming household per quarter acre, which would translate to a total of US$106,000-220,000 for 400 farm families partnering with Akili. An initial assessment found the approach could be quickly scaled to reach 20,000 households over five years, which would generate over US$14 million annually for farming households. Akili estimated agribusiness profits at US$76 million over five years, much of it designed for further investment in the farmers, showing the commercial potential of supportive, win-win farmer-buyer partnerships.

[2] Based on variation between low density vs. recommended density planting methods.

LESSONS LEARNED

RELATIONSHIPS

There is evidence that farmers can achieve significant gains when linked to a commercially-viable business that has the capacity to aggregate harvests and add value to the product. In particular, Akili's value addition, which involves dehydrating fresh spinach into spinach flakes, enables spinach farmers to connect to export markets that would be out of reach if all the farmers had to offer was fresh spinach, which is highly perishable.

BARRIERS/RISKS

Like all of us, smallholder farmers are inherently risk-averse and tend to make decisions to minimize risk as well as to maximize gains. They are also faced with huge risks in every aspect of agricultural production: the agricultural inputs sold to them are frequently fake, expired or developed for other crops; there are enormous production risks due to environmental stress or attacks from plant pests or disease; and there is a marketing/price risk with regards to finding buyers and getting a price that produces a profit. The vertically integrated value chain created by Akili addresses all these risks, which is a major incentive for smallholder farmers to participate in this type of organized value chain for agriculture products. But many farmers reported negative experiences with past contract farming or similar arrangements, and at times that proved to be a barrier to their participation in any partnership.

DONOR ROLE

Despite a solid business case for this type of production partnership, startup capital can be hard to obtain from commercial financiers. Donors could buy down the risk of initial investment by early adopters or they can facilitate, negotiate or guarantee access to loan products with financial services providers.

IOM PROBES HOW ICT SERVICES CAN SUCCEED IN THE AGRICULTURE SECTOR

Instead of Seeking to Serve an Agribusiness, Become an Agribusiness

ICT services for the agriculture sector have mushroomed. The features they offer include technical advice via virtual agriculture extension services; options for managing transport logistics; programs for monitoring and facilitating input purchases; the capacity to stay abreast of current market prices; links between producers to buyers; and assistance in helping farmers find credit and insurance.

Given the enormous potential of ICT services to create commercial opportunities in smallholder agriculture, IOM conducted a comprehensive analysis of what makes or breaks an ICT service provider and how ICT services are being successfully used in smallholder agriculture in sub-Saharan Africa.

The study revealed that agriculture applications of ICT are having a hard time finding commercial success in the region when packaged as standalone businesses. Rather, ICT is more successful when it is closely linked to—or is an actual part of—an ongoing agribusiness.

For example, former IOM partner iProcure Ltd. was struggling to find its footing working exclusively as an ICT business seeking customers in the agriculture sector. But then, working under the guidance of a new investor, it started a business selling inputs to farmers. Eventually, it accumulated a large amount of data on farmer buying habits and used these insights along with its ICT skills to forecast demand.

That forecast in turn allowed the company to make bulk purchases of farm inputs, which reduced its wholesale prices and allowed the company to offer a 15 to 20 percent discount to farmers. The move attracted more customers, who in turn provided more data.

Now, the ICT and agriculture aspects of its business model are inseparable. They are in a symbiotic relationship where one abets the success of the other.

Today, there is a lot of buzz around what ICT can do for agriculture in Africa. And the potential is indeed huge. But IOM has found that from a business standpoint, the focus should be equally on how agribusiness opportunities can provide a commercial foundation for launching an ICT business.

SECTION 4

Precision Soil and Plant Measurement for Evidence-based Agronomy

OVERVIEW OF ISSUE

There is a growing demand from governments, the private sector, development organizations and farmers for precise information on soil conditions in sub-Saharan Africa to guide investment decisions on use of proper fertilizer blends and other inputs. Soil composition can vary dramatically between different locations and current recommendations available to most farmers are too broad to be useful. Most have not been validated with current state-of-the-art soil testing technology, which makes it difficult for farmers to know if their investments in inputs will pay off in the form of increased yields.

4.1

Boosting Maize Yields: Is Soil Analysis Enough?

AGRICULTURE INNOVATION

IOM worked with the World Agroforestry Center to develop and execute an assessment of the center's new soil testing technology on hundreds of samples taken from farms in Machakos County, Kenya. The study sites featured multiple soil types where farmers were cultivating an assortment of different maize varieties.

In addition, local households were surveyed to learn more about current yields from maize, the main crop grown in the area, along with household income levels, availability of farm equipment and hired labor, and current maize yields. The survey was designed to capture key farm-based and household-based variables that also can have an impact on maize yields.

MEASUREMENT INNOVATION

- Using integrated risk and outcome probabilities to evaluate the returns to maize-related agricultural investments in Kenya
- Using an approach developed by the African Soil Information Service (AfSIS) to assess maize farming conditions, which emphasizes the use of statistically valid sampling frames to characterize soil deficiencies and crop responses
- Applying principal component analysis to determine precise soil typologies, associated soil fertility management recommendations and region-specific fertilizer blends
- Comprehensively evaluating household income status and how maize farmers view the socioeconomic risks and returns of adopting site-specific soil fertility management recommendations

KEY RESULTS

Testing shows that soils in the area were widely deficient in key soil nutrients that made them marginally suitable for maize production. And the most common fertilizers used in the area did not address the full range of nutrient needs. However, the study also revealed that soil characteristics are not the only factor that explains yield gaps from one farm to another. Soil testing must be combined with other data, such as plant tissue analysis, household income, availability of labor and knowledge and use of soil management practices, to give a meaningful estimate of whether investments in fertilizers will produce a profitable return.

LESSONS LEARNED

RELATIONSHIPS

There is need to build relationships that will provide the capacity to carry out soil nutrient studies in the maize production system over a longer period and screen soil nutrient enhancement options to ensure they match the local conditions. Fostering collaborative relationships between soil labs, agriculture research organizations and private sector fertilizer companies will also help address information gaps around maize nutrient requirements and improve the availability of locally adapted fertilizer blends.

BARRIERS/RISKS

It takes a long time to alter perceptions around input use. Although more accurate soil tests should lead to fertilizer blends that match specific soils and crop types, existing practices and opinions can be resistant to change and focused outreach and education efforts are essential.

DONOR ROLE

Greater collaboration is needed between development organizations and public institutions. For example, publicly funded research organizations have the tools for measuring the available soil nutrients in different areas and the capacity to conduct field trials to assess crop response to different fertilizer applications.

PART 3

ECONOMIC MODELS AND BUSINESS PLANS

Illuminating a Path to Profitability

As part of TechnoServe's commitment to quantitative rigor, the IOM team has a developed a series of comprehensive economic models and business plans that are used to evaluate and validate the commercial potential of various interventions targeting farmers, livestock keepers and allied agribusinesses.

In general, the objective for all IOM economic models is to establish an empirical framework that offers an incisive and accurate assessment of the commercial viability of business ventures targeting smallholder farmers, agribusinesses and livestock keepers in sub-Saharan Africa.

ECONOMIC MODEL STRUCTURE

The fundamental goal is to develop a framework that increases profitability for all involved compared to an alternative, business as usual scenario.

For farmers, the difference in farmer profitability $(\Delta\pi_{farmers})$ is defined as the difference between farmer profits when the innovation is in use $(\pi_{farmer,innovation})$ and those farmer profits under the alternative, business-as-usual scenario $(\pi_{farmer,alt})$. For farmers, profits are typically given as $\text{Area} \times [(\text{Price} \times \text{Yield}) - \text{Unit Cost}]$.

The same applies to the agribusiness, where the difference in agribusiness profitability $(\Delta\pi_{agbiz})$ is given by $(\pi_{agbiz,innovation}) - (\pi_{agbiz,alt})$. This approach is critical because it enables the evaluator to focus on the few variables affected by the innovation, assuming ceteris paribus for the myriad other variables influencing firm profitability. This results in a very efficient evaluation process, which is still highly accurate, since it places emphasis and effort in the estimation of those variables, which are the greatest drivers of the desired result $(\Delta\ profitability)$.

CALCULATING COMMERCIAL VALUE

The commercial value of the venture can be given by the sum of the profitability of all parties:

$Commercial\ Value = n\Delta\pi_{farmer} + \Delta\pi_{agbiz}$, where n is the number of farmers. This enables us to calculate the Return on Program Investment (ROPI), the key measure of the value of the Gates Foundation/ TechnoServe investment, calculated as: $\text{Commercial Value} \div \text{Total Program Investment}$

The IOM team calculates estimates for the pilot period and for three years after the pilot, a more realistic timeframe given the long-term impact of our work.

ROLE OF THE BUSINESS PLAN

Assuming that the venture is profitable, the business plan then provides guidance to potential investors, focusing on four key metrics:

1. How much investment (capital expenditure/capex and working capital) will be required to launch the venture?
2. When will the venture break even?
3. How long will it take for the venture to recover its investment cost?
4. What is the rate of return on investment?

The rate of return is the most important indicator of the quality of the investment, and while there are many methods of calculating, we chose to use the **modified internal rate of return (MIRR)**, which is frequently used to compare the estimated returns to different investment opportunities. The MIRR is calculated as the interest rate (r) that satisfies the equation below.

$$MIRR = \sqrt[3]{(FV \text{ of 3-year returns} \div PV \text{ of initial investment}) - 1}$$

The following sections explore economic models, business plans, and assessments of returns on program investment developed for Akili's spinach production partnerships with smallholder farmers; Equator Seeds' use of drone-assisted mapping and geospatial monitoring services; and the mobile delivery of livestock health services targeting pastoral herding communities.

Akili Spinach Production Partnership

Economic Model, Business Plan, Return on Program Investment

ECONOMIC MODEL

IOM developed an economic model to assess Akili's approach to spinach production, seeking to answer a number of questions, including:

- Is Akili commercially viable?
- What is the value created for farmers and other actors?
- Does the spinach program reduce farmer risk and, if so, what is the value of the risk reduction?
- Are financial benefits sufficient to transform farming from subsistence to commercial?

IOM began the modeling with the hypothesis that Akili's model results in significantly increased returns to both farmers and agribusinesses. In this scenario, the commercial value of the Akili model is a composite of change in farmer profitability ($\Delta\pi_{farmers}$) and change in agribusiness profitability ($\Delta\pi_{agbiz}$) as denoted below:

$$Commercial\ Value = \Delta\pi_{farmers} + \Delta\pi_{agrbiz}$$

The change in farmer profit is the difference in profitability between Akili farmers involved in spinach production ($\pi_{Ak\ farm}$) and alternative farmers ($\pi_{alt\ farm}$).[3,4]

Also, since Akili's spinach program significantly reduces risks for participating farmers, IOM modeled the individual farmer profitability where risk is mitigated compared to alternative farmers with no risk mitigation. The regular farmer faces three main types of risk: (1) input quality risk; (2) production risk; and (3) marketing/price risk. Participation in the Akili model essentially removes all those risks through a combination of advice on agronomic practices, extension and monitoring services, access to inputs, guaranteed price and crop insurance.

Meanwhile, by providing farmers with a strong regimen of support, Akili reduces the overall uncertainty regarding expected harvests, which in turn lowers operating costs by reducing the price of the premium they pay to insure participating farmers and their crops.

Models for engaging farmers in longer-term supply relationships have shown the potential to deliver significant benefits for farmers and agribusinesses when there is a commercially viable plan to aggregate and add value to the farmer's harvest while reducing farmer risks. Benefits for farmers and Akili from the spinach production partnership are shown below.[5]

[3] $\Delta\pi_{farmers} = \sum_{n=1}^{n} \pi_{Ak\ farm} - \sum_{n=1}^{n} \pi_{alt\ farm}$

[4] $\Delta\pi_{agbiz} = \pi_{agbiz}$ because the spinach program was newly launched under the pilot.

[5] The worst-case scenario is based on sub-optimal planting practices resulting in 50% of anticipated production per acre.

FARMER BENEFITS

Variable	Unit	Worst Case Scenario	Expected Value (mean)
Spinach farm-gate price	KES/Kg	10	10
Premiums paid by Akili for crop and health insurance	KES/Kg	0.71	0.71
Area cultivated (A)	Acres	0.25	0.25
Yield per quarter acre per season (Y)	Kg	1,036	2,072
Number of seasons per year	#	4	4
Total annual production	KES/Year	4,152	8,288
Annual cost of inputs (C)	KES/farmer	17,124	31,656
Annual farm revenue	KES/farmer	44,382	88,764
Annual farm profit	**KES/farmer**	**27,258**	**57,108**
Annual farm profit ($US)	**US$/ Farmer**	**265**	**554**

Annual farmer profits under the alternative business-as-usual scenario are estimated at KES12,000 (US$119) per quarter-acre plot.[6] However, these profits are highly uncertain, and cannot be compared one-to-one with their near-certain profits under Akili. To enable this comparison, the IOM team has modeled the effects of eliminating these risks on the welfare of the farmer, drawing on TechnoServe's long track record of engagement with farmers and insight into farmer behavior. Modeling farmer utility under various assumptions supported by anecdotal information from farmers in the region,[7] the certain annual profit of KES7,670 is equivalent to uncertain profit of KES12,000.[8] This represents a "loss" of KES4,330 (12,000–7,670) or 36 percent of value due purely to uncertainty. The table below shows comparable (uncertain) profits under the Akili and business as usual scenarios based on this analysis.

Variable	Unit	Worst Case Scenario	Expected Value (mean)
Certain Farm Profit – Akili	US$/ Farmer	265	554
Uncertain Farm Profit – Akili	US$/ Farmer	361	756
Uncertain Farm Profit – Alternative	US$/ Farmer	119	119
Difference = Farmer impact	US$/ Farmer	242	638
3-year farmer profits	**$US**	**$872,043**	**$2,295,016**

[6] Normally distributed with standard error 1.39 and standard deviation KES16,700, Mathenge et al, Tegemeo Institute, 2012.

[7] Loss aversion, suggesting an s-shaped utility function (http://excen.gsu.edu/fur2012/fullpapers/xgassmann.pdf), (http://harvestchoice.org/labs/risk-and-smallholder-farmer), where the coefficient of loss aversion $\lambda = \frac{u'(0^-)}{u'(0^+)} > 0$, $\alpha = \beta = 0.88, \lambda = 2.25$ (Kahneman et al, 1979)

[8] $u(x^0) = \int_{-\infty}^{0} -\lambda(-x^\alpha)P(x) + \int_0^{\infty} x^\alpha P(x)$, where x is income and $x^0 = 12{,}000$

$$\text{Thus } u(x^0) = \int_{-\infty}^{0} -\lambda(-x^\alpha)\frac{1}{\sqrt{2\pi\sigma^2}}e^{\frac{(x-\mu)^2}{\sigma^2}} + \int_0^{\infty} x^\alpha \frac{1}{\sqrt{2\pi\sigma^2}}e^{\frac{(x-\mu)^2}{\sigma^2}} = 2{,}622$$

$$u(x^0) = x^\alpha \text{ (because } x^0 > 0\text{), so } u(x^0) = 2{,}622 = x^{0.88} \rightarrow x^0 = e^{\ln(2622)/0.88} = 7{,}670$$

AKILI BENEFITS

Variable	Unit	Mean			
		Year 1	Year 2	Year 3	3-year Total
# of Farmers	#	400	1,600	2,000	2,000
Total Production	Kg	3,321,600	13,286,400	16,608,000	33,216,000
Annual Revenue	$	$1,011,912	$4,047,647	$5,059,558	$10,119,117
Total Costs	$	$691,173	$2,609,854	$3,249,415	$6,550,442
Agribusiness Profits	**$**	**$320,739**	**$1,437,792**	**$1,810,144**	**$3,568,675**

Agribusiness Capital Investment & Cash Flow Estimates

Based on the Akili model, an entrepreneur will require about US$150,000 in capex (equipment and setup) costs and a further US$31,000 in working capital for the first two seasons, a total of US$181,000 in initial investment. The venture breaks even after season three (nine months) and the investment is recoverable after season five (15 months) from the start of all operations. Break-even will be achieved with the participation of at least 56 farmers (minimum 112 farmers). The venture will require a further US$582,000 in capex investment to reach its optimal scale (2,000 farmers producing over 33,000 tons/season), which it can achieve in year three, earning profits of over US$2.25 million per season (US$10 million/year).

Return on Investment

Program costs are estimated at US$421,624. During the pilot period, 400 farmers completed two seasons of production, gaining a total of US$48,400, and Akili estimates that they were able to break even, for a total commercial value of US$48,400. This represents a ROPI of 11 percent.

Over three years, based on the above estimates, farmers gain US$2.3 million and Akili US$3.6 million, generating a ROPI of US$5.9 million/US$421,624 or US$13.9 (minimum 6.1) in commercial value for every US$1 spent.

Akili's 3-year business MIRR is calculated as:

$$MIRR = \sqrt[3]{(FV \text{ of 3-year returns} \div PV \text{ of initial investment} - 1)} = \sqrt[3]{(FV\ (US\$3.6\ million)/US\$763{,}000 - 1)} = 68\%$$

Equator Seeds Drone-assisted Mapping and Geospatial Monitoring Services

Economic Model, Business Plan, Return on Program Investment

ECONOMIC MODEL

To guide in estimating the impact of the use of drones, the project developed an economic model based on the following basic assumptions that the use of drones results in: (a) reduced costs of crop monitoring; (b) reduced costs of pesticides and fertilizer application; (c) increased amount of farmer (land) over time; and/or (d) increased returns, to agribusinesses and farmers.

The benefits of the drone program are given by:

$$Commercial\ Value = \Delta\pi_{agbiz} + n \times \Delta\pi_{farmer}$$

Where: $\Delta\pi_{agbiz}$ denotes the changes in Equator Seeds' profits, n is the number of famers in the out-grower scheme and $\Delta\pi_{farmer}$ is the change in farmer profits. The total additional return for the agribusiness $(\Delta\pi_{agbiz})$ is defined as the difference between agribusiness profits using the drones (π_{UAV}) and profits without the drones (π_{Alt}) as shown below.

$$\Delta\pi_{agbiz} = \pi_{UAV} - \pi_{Alt}$$

The total change in agribusiness profits are estimated as:

$$\Delta\pi_{agbiz} = \sum^{all\ crops} [(\overline{P - P_f}) \times (\bar{n} \times \bar{A}_{crop} \times \Delta yield_{crop})] - \Delta C_{UAV}$$

Where:

- $\bar{P}$ and $\bar{P}_f$ are the average price per acre at agribusiness and for farmers respectively
- $\bar{A}_{crop}$ is the average area under cultivation of each crop
- $\Delta yield_{crop}$ is increased crop yield as a result of monitoring using UAV
- ΔC_{UAV} is the change in the cost of monitoring and
- UC_{crop} is the change in the per acre farm cost of production due to the use of UAV
- n is the number of farmers

The change in farmers' profits is:

$$\Delta\pi_{crop} = \bar{n} \times \bar{A}_{crop}\ [(\bar{P}_f \times \Delta yield_{crop}) - (\Delta UC_{crop})]$$

By increasing production and reducing the need for inputs, using drones as a crop management tool can deliver significant financial benefits for farmers and agribusinesses.

1. **NO MORE BLANKET PESTICIDES APPLICATION:** The drone enables the shift from three blanket rounds of pesticide application to one blanket round and one precision application covering 11percent of the farm. The costs of pesticides are estimated to drop by US$69/acre for maize and to increase by US$4 for beans and soy, a 37 percent drop in the average cost of pesticides.

2. **INCREASED COST OF FERTILIZER:** Similarly, the drone enables the shift from blanket to precision top dressing fertilizer application, resulting in a US$57 drop in fertilizer cost for maize, and US$3 for beans and soy, a 38 percent drop in the average cost of fertilizer application.

3. **NET CHANGE IN COST:** The net change in production cost (-US$126 for maize and +US$1 for beans and soy) while producing considerable environmental benefits.[9]

4. **REDUCTION IN YIELD LOSSES:** Earlier pest identification and more optimal application of fertilizer were observed to reduce farms losses by 14 percent and 15 percent each cropping year, effectively increasing maize production by 4,300 Kg/year and beans and soy, production by 2,680 kg/year.[10]

Farmer Benefits

By boosting production per acre, and decreasing input costs, the drone monitoring system generates the following benefits for farmers:

- US $1,800 profit for maize seed production
- US $1,800 profit for bean seed production
- US$1,500 for soy seed production

BUSINESS PLAN

Equator Seeds Benefits

In addition to farmer benefits, Equator Seeds benefits enormously from the introduction of drones. First, their sales volumes rise as production rises on their own farms and those of their out-grower farmers. The supply for quality seed in Uganda is so limited that they have no problem selling the additional volume, meaning that the company gains (US$1.4-$1.9) additional profits for each additional Kg produced by their farmers.

The additional cost of implementing the drone program is estimated at US$152,000 in capex, including acquisition of 10 drones and setup, staffing and training in support of a new GIS unit/ department responsible for data collection, analysis and reporting to field agronomists.[11] The unit will require an additional US$15,000/year in running costs and more significantly, will require major institutional and structural changes to accommodate the new approach to farm monitoring. Equator Seeds has expressed their desire to immediately expand this program to all their farms with a year, but the IOM team has modeled a more gradual expansion to 12,000 farmers over the next three years. As shown in the table below, the additional profits far outweigh the additional cost of the drone-based farm monitoring, with break-even on positive returns being achieved in the first year of operations.

Second, their improved monitoring capacity enables the expansion of their out-grower scheme to more farmers. The table below demonstrates a business plan for Equator Seeds to follow in rolling out drone technologies.

[9] M. Hosseini, M. Chizari, M. Bordbar, Evaluation of the possibility of precision agriculture from the view point of Agricultural experts in Fars Province Iran Agric Exten Edu, 6 (2) (2010), pp. 35-47.

[10] Based on ES agronomy data on base yield, average 3.38 acres/farmer.

[11] The 10 drones can monitor a minimum of 12,000 farmers.

PHOTO: ILRI/DUNCAN

Break even number of clients

To offset the capex cost of US$152,000, Equator Seeds will need to ensure that between 30 and 81 acres are put under production of maize to break even. This requires 24-69 farmers each cultivating 3.38 acres of maize, assuming 100 percent is farmed by out-grower farmers.

Variable	Year 1	Year 2	Year 3	3-Year total
Number of Farmers	270	4,000	12,000	12,000
Incremental Revenues	$2,318,196	$8,585,910	$34,343,638	$45,247,743
Incremental Cost	$460,053	$617,551	$1,822,281	$2,899,885
Incremental Profits	$1,858,143	$7,968,358	$32,521,357	$42,347,858
Farmer Benefits	$466,251	$6,907,429	$20,722,286	$28,095,966
Commercial Value	$2,324,394	$14,875,787	$53,243,643	$70,443,824

Return on Investment

The cost of the program was estimated at US$587,630. The commercial value of the pilot was estimated at US$2.3 million (ROPI: 4.0). Over three years, the commercial value is estimated at US$70.4 million (see table above), generating a ROPI of US$120 for every US$1 spent.

The incremental Equator Seeds profits of US$53 million from an expenditure of US$152,000 represents a MIRR of 605 percent, evidence of the truly transformational nature of the shift from ground-based to remote farm monitoring.

Mobile Livestock Services

Business Plan and Return on Program Investment

The livestock services business plan shows how offering mobile livestock services through points of livestock aggregation is likely to generate additional incomes for pastoralists and profits for commercial veterinary service providers.

Pastoralists, enjoy two benefits:

- **IMPROVED VACCINATION RESULTING IN IMPROVED HERD HEALTH:** IOM anticipates a 40 percent increase in vaccination and reduced risk of counterfeit products and fraudulent services, leading to a 15 percent reduction in herd sickness and a 14 percent reduction in herd mortality. These numbers translate into value in terms of increased milk production, the value of the animals themselves and the value of future calves born from surviving livestock.

- **REDUCED COSTS:** Despite increased expenditures on vaccinations, a net 15 percent in cost-savings is anticipated, based on reduced costs of treating sick and dying animals, and reduced traveling and lodging expenses incurred by pastoralists who journey to distant towns to purchase supplies.

PASTORALIST BENEFITS

Parameter/Variable	Unit	Change (Innovative mobile scenario – BAU scenario)
Change in annual herd vaccination rates	% of herd	+40%
Change in annual herd sickness rate	% of herd	+15%
Change in annual herd mortality rate	% of herd	+14%
Change in annual cost	USD/year	-$458
Average herd size	Head	225
Change in annual value of surviving animals	USD/year	$5,489
Change in annual value of calves born from surviving livestock	USD/year	$549
Change in annual value of milk production from surviving animals	USD/year	$618
Annual value of total benefit	USD/year	$7,441

PHOTO: KELLEY LYNCH/USAID ETHIOPIA

BUSINESS PLAN: COMMERCIAL SERVICE PROVIDER BENEFITS

The table below shows estimated agribusiness profits over the first three years, assuming a modest, realistic growth rate. Note that the labor-intensive nature of pastoral production and agrovet operations result in the creation of over 15,000 jobs over the three years.

Variable	Unit	Pilot	2018	2019	2020	3-year Total
Farmers served	#	2,496	6,000	15,000	20,000	20,000
Incremental Agribusiness Profits	USD	$364,810	$1,052,338	$2,850,081	$4,092,424	$7,994,884
Total Benefits (for all farmers)	USD	$18,573,497	$44,647,828	$111,619,571	$148,826,094	$323,666,989
Jobs created	#	870	2,091	5,228	6,970	15,158
Commercial Value	**USD**	**$18,938,307**	**$45,700,166**	**$114,469,652**	**$152,918,519**	**$332,026,643**

Agribusiness Capital Investment & Cash flow Estimates

An initial investment of US$30,000 is required for every route serving a maximum of 2,500 farmers. The venture breaks even in the third quarter and the investment is repaid within the first year—an astonishing return. A maximum market share of 20,000 clients is assumed for a single agribusiness, as others crowd into this new but highly lucrative sector.

Return on Program Investment

Program costs are estimated at US$225,800. During the pilot period, 2,496 farmers gained a total of US$18.5 million and agrovets a further US$196,000—a total commercial value of US$18.9 million. This represents a ROPI of US$84 for every US$1 spent. Over three years, based on the above estimates, farmers gain US$324 million and agrovets US$4.3 million, generating a ROPI of US$328 million/US$255,800 or US$1,471 in commercial value for every US$1 spent.

The three-year agrovet MIRR is calculated as:

$$MIRR = \sqrt[3]{(FV \text{ of 3-year returns} \div PV \text{ of initial investment} - 1)} =$$
$$\sqrt[3]{(FV\ (US\$4.09\ million)/US\$210{,}000 - 1)} = 169\%$$

Summary of Overall IOM Returns

Overall IOM ROPI:

- Pilot period = 13.9
- End 2018 (two-year) = 98

Business investments of US$1.125 million generate US$61 annually after three years (MIRR = 278%)

PART 4

CONCLUSION: THE CRITICAL NEED FOR INNOVATION IN OUTCOME MEASUREMENT

Today there is widespread consensus across sub-Saharan Africa that building a modern, productive and profitable agriculture sector anchored by smallholder farmers has the potential to generate economic benefits that will be experienced at all income levels. But delivering the strategies and innovations that can translate this potential into reality remains an often-vexing challenge.

As more actors from the public and private sector seek winning formulas for agriculture development in Africa, conducting rigorous pilot testing of particular innovations to find a formula for bringing them to scale has assumed increasing importance. IOM has worked to develop a process for selecting and piloting innovations that can help identify what is most likely to work for African farmers and African agribusinesses.

After two years of work identifying and piloting a wide assortment of agriculture innovations, several key lessons emerged that are applicable to agriculture donor projects around the world. The following is a summary of key insights generated by IOM's work.

1. **CHOOSE INNOVATIONS TO PILOT THAT CAN BE LINKED TO A CLEAR BUSINESS MODEL:** It is important to consult the relevant literature and other experts to clarify that a sustainable, credible business model exists for driving widespread adoption of a particular agriculture innovation. Progress in the African agriculture sector is often hindered by an overreliance on donor or government funding, which, even with the vagaries of the market, is not a reliable agent of lasting change compared to success in the business sector. Our scoping work included face-to-face interviews and meetings with multiple actors involved to establish that an innovation had a good chance of being commercially sustainable. We also developed a system for identifying partners who were fully committed to the commercial development of their innovation. And we turned down opportunities to conduct pilot tests of seemingly promising innovations if that commitment was lacking.

2. **DONORS CAN SET TARGETS FOR PERFORMANCE THAT DISTORT RESULTS:** It's understandable that donors want to set targets for pilot projects to ensure that projects are well-managed. But these targets can end up distorting the goal of producing reliable data. For example, a partner initiative had a donor-set target number of businesses to be supported. But one of the businesses recruited appeared to be more concerned about obtaining donor dollars than making a business case for their services. That left the project coordinator with a difficult choice: keep the partner involved to satisfy donor requirements or remove them from the pilot to ensure higher quality outcome data. After several rounds of deliberation, the latter course was chosen, but not without major difficulties and certainly at high risk. Ideally, project targets should be treated with enough flexibility, without sacrificing their critical role in ensuring goal orientation and oversight. Implementers must also resist a tendency to be risk-averse when it comes to notifying funders about the need for a course correction.

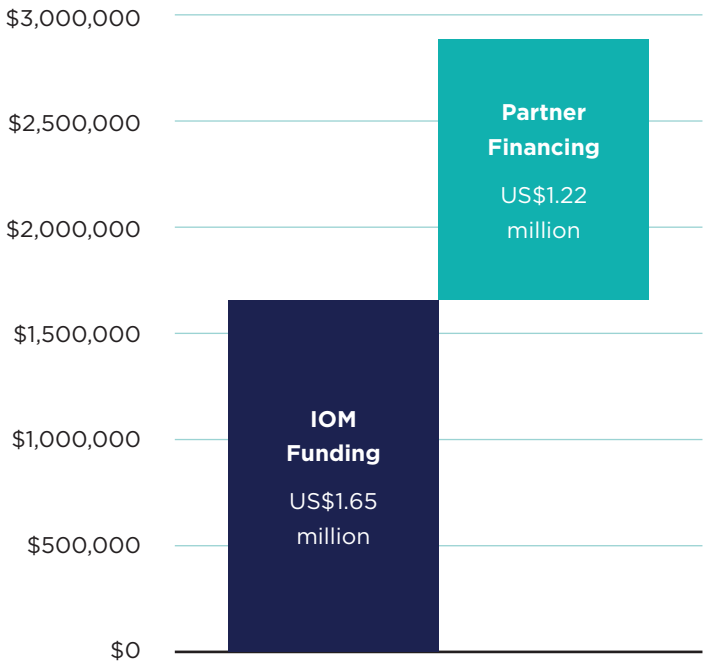
3. **PILOT PROJECTS NEED TO PAIR RESEARCHERS WITH PRIVATE SECTOR ACTORS WHO CAN PROFIT FROM THEIR INNOVATION:** Too often, agriculture innovations are tested in Africa via partnerships between Western and African research institutions. Successful models from places like the United States or Europe involve public-private partnerships, which yield much more robust outcomes in terms of providing a roadmap for commercial scale-up. Yet researchers and business-owners work in very different worlds and often have a hard time communicating. We bridged this gap by involving private sector partners at the design stage of the pilot project. That way, the technical aspects of the innovation were addressed alongside fundamental business considerations, such as delineating the capital investment required, the break-even point and specific variables that could drive profits or losses.

4. **DEVELOPERS SHOULD NOT UNDERESTIMATE THAT RISK AVOIDANCE IS A POTENT MOTIVATOR FOR SMALLHOLDER FARMERS:** The undeveloped market ecosystem around African agriculture has led to the situation where the entire range of risks associated with agriculture (input quality, production, climate, pest and price) are borne by a single actor: the smallholder farmer—who is being crushed by the weight of those risks. Risks also are greater in African agriculture due to the poor regulatory systems that allow for the proliferation of fake seeds and fertilizers. And factors that reduce risk in developed countries, such as crop and livestock insurance, long-term contracts and product guarantees, remain rare. Understanding this, we should not be surprised at the limited adoption by smallholders of (costly) agriculture innovations associated with risky returns. Developers of agriculture technologies such as advanced soil testing capabilities or improved crop varieties often fail to understand that, for smallholder farmers in Africa, risk avoidance is generally a more potent motivator than the prospect of high yields and big profits. For example, farmers may continue to plant poor yielding maize in low-quality soil because even in a worst-case scenario they know they will have leaves and stalks for feeding their livestock. Innovations are more likely to be widely adopted when tested in ways that take into account all of the potential risks and benefits a farmer may be considering. In general, African farmers are more likely to choose an innovation that offers a certain, if moderate, gain versus one that may promise major gains, but will be perceived by them as holding substantial risks.

By adhering to our carefully designed process for selecting and evaluating innovations that could have a major impact on the economic performance of the African agriculture sector, we have compiled an impressive record of achievement. Our total programmatic investments were US$1.65 million and partner contributions totaled US$1.22 million. The value of project impact (gain in revenue for pilot farmers and agribusinesses) is estimated at US$23 million, a US$14 return for every US$1 of program. But the real benefit is the continuous permeation of these profit-generating innovations into the marketplace. Modeling modest expansion of pilot agribusinesses and "crowding in" of a small number of copycat businesses, this impact is projected to rise to over US$160 million by the end of 2018 with no further program intervention. This represents two-year returns of over US$98 for every US$1 of program investment—a measure of the power of the private sector to generate enormous profits with the right information and guidance in place.

Key IOM achievements are summarized below in charts and a table.

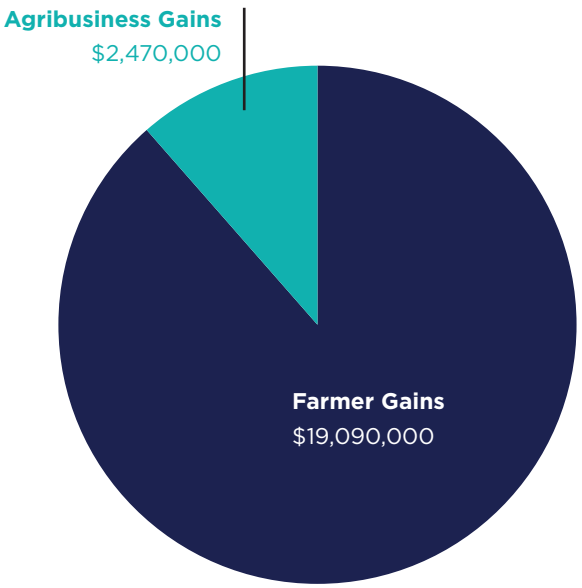
ADDITIONAL FUNDING LEVERAGED VIA IOM PARTNERSHIPS



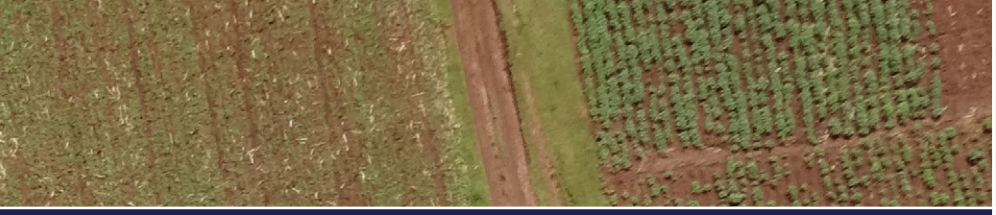
IOM INDICATOR RESULTS HIGHLIGHTS

Indicator	Unit	Pilot Results	Projected to 2018
Measurement innovations tested	#	17	–
Agricultural innovations tested	#	12	–
Smallholder beneficiaries	HH	3,166	14,984
Value of program impact	$US	$23,000,000	$161,200,000
Return to $1 of BMGF investment	–	14	98

IOM PILOT PROGRAM IMPACT BY BENEFICIARY



Today there is widespread consensus across sub-Saharan Africa that building a modern, productive and profitable agriculture sector anchored by smallholder farmers has the potential to generate economic benefits that will be experienced at all income levels.



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