

POLICY BRIEF

INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT) SOLUTIONS FOR INCLUSIVE AGRICULTURAL VALUE CHAINS

The Catalytic Sustainable Agribusiness Investment (CSA-I) project aims to accelerate the deployment of capital into climate-smart-agriculture enterprises and projects. A central goal of the project is to improve the enabling policy environment for CSA investment. Given increasing interest by businesses and investors, this brief examines the role of emerging ICT solutions in building inclusive and sustainable agricultural value chains and enhancing investment attractiveness.

I. Executive Summary

Information and Communication Technology (ICT) solutions are increasingly being applied to agricultural value chains. Building on consultations with stakeholders and desk research, this brief presents the results of an assessment of five key services provided by ICT-for-agriculture solutions: **Information Sharing, Information Analytics, Access to Markets, Access to Finance, and Tracking and Traceability (T&T)**. The assessment reveals that, while these solutions can and do generate real farmer impact, there are few ready, workable, and sustainable business models for private ICT start-ups. Additional public and private support can overcome many barriers to enable broad and sustainable impact.

Key Findings

Data-sharing can be the base for mutually beneficial partnerships and provide revenue streams to ICT solution providers. Many ICT companies have access to detailed information on their users but may be unaware of how to monetize the data. Start-ups should seek out data-sharing arrangements with value chain partners early in the business development process to justify investment into information analytics while maximizing impact and generating new revenue.

Governments can invest in supporting infrastructure and training for ICT. The successful uptake of technology depends on public provision of infrastructure like power grids, telecom services, and improved roadways. Governments can also promote mobile phone usage, invest in expanding the digital literacy of farmers, and work to improve ICT incubation and accelerator ecosystems with agricultural development objectives.

Blockchain technologies have the potential to transform ICT business models, but it presents its own challenges. The distributed nature of blockchain allows it to increase trust and transparency in systems while lowering costs, increasing efficiency, and enabling broader uptake. However, its benefits are dependent upon a network effect that can entail high upfront costs to achieve. As such, companies should carefully consider the costs and benefits of adopting blockchain before investing.

ICT solutions that provide access to finance may serve as an entry point for impact investors. Many investors prefer digital solutions over ICT solutions that deal with physical inputs or products. Enabling access to finance for smallholders can serve as a bridge between digital and physical service provision. Financial technologies are a key area of growth for agricultural ICT solutions in developing countries.

2. Introduction: Unlocking the Potential of ICT and Agriculture

This brief provides context for the current landscape of ICT in agricultural value chains and examines the key barriers and opportunities for further growth. First, we conduct an assessment on the characteristics of existing ICT solutions and pair the results with desk research to analyze their potential impact on agricultural value chains. Next, we identify barriers that these solutions encounter when attempting to reach scale and discuss two major case studies in which technology could be used to transform the value chain. Last, we briefly examine the current investment ecosystem for these ICT solutions in agriculture and offer recommendations to increase investment.

ICT solutions can address a wide range of gaps and inefficiencies in agricultural value chains. ICT solutions, as a subset of the larger AgTech field, have three primary applications to value chains. First, ICT can facilitate or strengthen market linkages and provide accessibility to otherwise informal and/or unorganized populations. Second, value chain actors can enhance their production through improved efficiency and quality by integrating ICT solutions into market operations and internal and external management systems. Last, ICT can allow for better understanding, transparency, and service delivery to farmers, customers, and the value chain in between through advanced data collection and analytics. As blockchain and other technologies are further explored, there is potential to further enrich existing ICT services and also to offer new ICT solutions to value chains and farmers.

Within ICT, blockchain technology is finding an increasing number of applications. This brief also examines the role of blockchain and the initiatives that have emerged to explore its applicability to different challenges in agricultural value chains, including traceability (IBM, Nestlé, Unilever and others),¹ food safety, (Wal-Mart and IBM's Blockchain Food Safety Alliance in China),² poverty and food insecurity (the Kenyan government's Blockchain and Artificial Intelligence Task Force),^a and financial inclusion (IBM and Twiga Foods).³



Information Sharing allows for the communication and receipt of information and knowledge between two or more actors



Access to Markets includes digital marketplaces for the buying or selling of various inputs, goods and/or services; enhanced internal systems for supply chain or aggregator management; and strengthened external market linkages



Tracking and Traceability (T&T) uniquely identifies products as it travels through a supply chain (tracking) or for downstream actors to pinpoint origination (traceability)



Information Analytics conducts data analysis and communicates results to either external customers/partners or for internal reporting and efficiency



Access to Finance facilitates payments, provides credit, or manages collateral; can also provide financial data to third parties that will then offer these or other financial services to farmers

^a The Blockchain and AI task force is set up to examine the application of these advanced technologies to Kenya's Big Four agenda, which includes a pillar on food security.

ICT solutions can have transformative impact at all levels of the value chain and across public, private, and civil society stakeholders. Given the breadth of applications available in the market, this brief looks at a subset of solutions categorized into five services: information sharing, information analytics, access to markets, access to finance, and tracking and traceability.

3. Typology of Existing ICT Services for Agriculture

We assessed a total of 55 existing ICT solutions in developing-country agricultural value chains, with an emphasis on Kenya and other sub-Saharan African nations. Assessment criteria included the organization type, information on the ICT solution, and the design architecture of the ICT service (See **Table I** for a full list of criteria). The majority of solutions assessed were relatively early-stage private start-ups that operate within a single country or region and typically target smallholders within multiple crop and/or livestock value chains. A small subset of these solutions is managed by non-profit or government agencies. Public initiatives included in the assessment have generally operated for longer time periods when compared to both small and large private-sector solutions. See **Figure I** for a distribution of each service in the assessment, and **Figure 3** for how ICT services apply to each component of a typical agricultural value chain.

Topic	Category	Indicators
Organization Information	Lead Organization Type	Government/Public; Large Private; Small Private; NGO/CSO
	Stage of Product	Concept/Seed; Pilot; Early/Growth; Functional
	Geographic Target	Single Country; Regional; Global
Solution Information	Services Offered	Information Sharing; Information Analytics; Access to Markets; Access to Finance; Tracking & Traceability
	Beneficiaries	Producers; Aggregators; Traders; Processors; Exporters
	Average Farmer Profile	Smallholder/Bottom of the Pyramid; Small to Medium; Largescale/Industrial
	Sectors	Single Commodity; Multiple Crop Sectors; Livestock Sectors; All (Crop + Livestock)
ICT Design Architecture	Technology Utilization	Mobile Phones; Computer/System-Based; Blockchain; Digitalization; other
	Service Delivery Model	All Digital-Based; Integrated Digital/Physical Delivery
	Accessibility	Subscription-Based; On-Demand; Through Service Provider; Agent-Based

Table I | ICT Solution Assessment Criteria

The vast majority of ICT platforms offered two or more services. Nearly 80% of all solutions offered multiple services on their platforms, with over half offering three or more services. Of those that were single-service only, a third were for information sharing. The tendency to provide for multiple services is rooted in the largely opaque, decentralized, fragmented, and often political nature of agricultural value chains and the interdependent nature of the solutions and services to address major challenges.



Information Sharing. Information sharing was the most commonly observed service in the assessment, appearing in more than two-thirds of all solutions. It is also the most likely to be offered on multi-service platforms. Information was previously shared through word of mouth, via extension officers, or through more basic technologies such as radio. Most ICT solutions utilized mobile phones, which allow for a vastly expanded reach, and targeted farmers as the key beneficiary. Access is most often granted through subscription-based services (that charge a fee after certain time periods i.e., monthly, weekly, daily, etc.) followed by on-demand access (that generally charge a fee by number of uses). One example of an information sharing platform is

iShamba: farmers subscribe to receive tailored information on market prices, weather, and agronomic advice based on their location and crop type.⁴

Farm management^b was the most likely type of information to be communicated to beneficiaries, followed by markets, then risks.

Farmers commonly face a lack of technical expertise, low farmer market power, and high vulnerability to risks from pests, diseases, climate change, and/or other weather-related events. Farm management is likely offered given the recognized need for improved farm management practices combined with the difficulties in expanding the reach of public or private extension services. In market information services, asymmetries between farmers and buyers stymie productivity and reduce the efficiency of markets. Communicating the information still presents logistical challenges for farmers, such as the physical transport of the production.⁵ The fewest services offered information on risks, despite the value in alerting farmers of impending shocks to allow them time to adopt preventative measures and minimize damages.

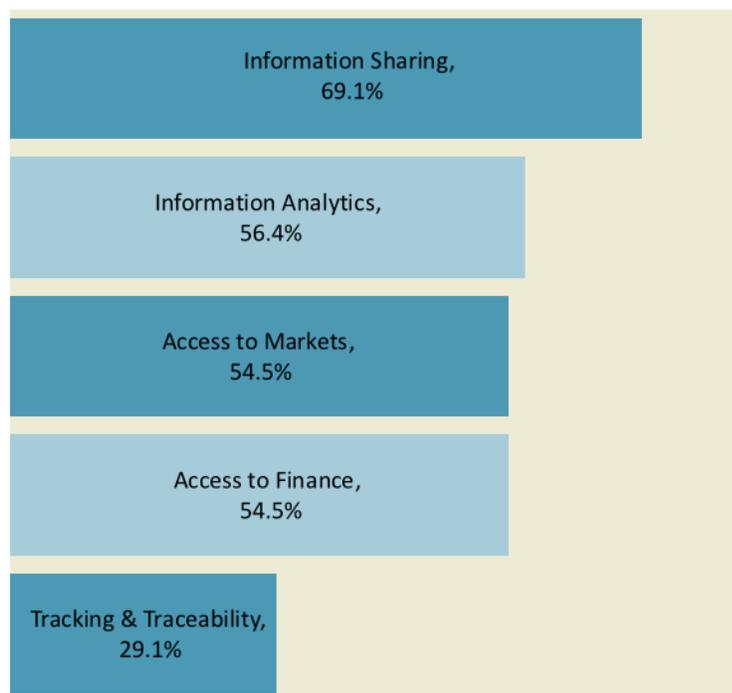


Figure 1 | % of ICT solutions offering each service



Information Analytics. Over half of solutions included an information analytics service, making it the second-most common service observed. Information analytics platforms are usually bundled with other services (see **Figure 2**). Additionally, information analytics services were often closely related to Access to Finance (See “Access to Finance” section below). It is more common for information analytics to be paired with a sharing component than it is for an information sharing platform to be paired with an analytics service. This likely reflects the higher costs entailed for introducing data analytics systems.

Analyzed data can be used to improve the provision of services.

Services that collect information on farm conditions can inform the types of information shared with farmers, such as sharing tailored and targeted assistance packages.⁶ Other types of information analytics can result in improved systems management and reduced administrative costs for upstream supply chain actors, such as farmer aggregators or processors. Other, non-commercial applications include agricultural research and knowledge-sharing with public institutions. One example is Ghalani, which provides integrated farm management software for small and medium enterprises and supply chain management for agribusinesses, including tracking and traceability. The data— including labor, money flow, yields and incomes⁷— is self-

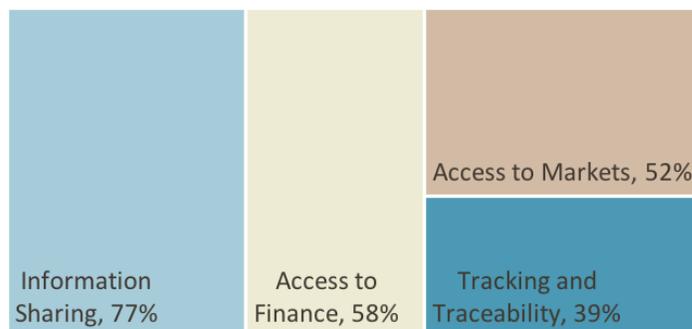


Figure 2 | On multi-service platforms with Information Analytics, how often other services appear

^b This brief focuses on information sharing for farm management, markets, and risks. The FAO has identified four information categories, including: short-term productivity, crisis management, long-term productivity, and risk management. The Sustainable Trade Initiative differentiates between agronomical and market information while the World Bank’s divides information services into “agricultural extension and advisory services,” and “agricultural learning and education systems.”

reported by farmers and provides real-time farm reports that allow businesses to understand their operations and make targeted improvements.⁸



Access to Markets. This service works to enhance market efficiency through:^c 1) digital marketplaces that provide an additional outlet for buying and selling of commodities; 2) improving supply chain management with improved internal processes; and 3) strengthening external market linkages via relationship facilitation within value chains, such as accessing needed inputs and resources. These services appeared in over half of all solutions and

were the most likely to target downstream actors. Often, the service model for access to markets requires the physical delivery of a product to the producer, unlike information services applications and access to finance, which can be delivered digitally. One solution, M-Farm, allows for both group buying and selling: farmers can aggregate their production through centralized drop-off points to reach higher-value buyers, and they can also have group-buying to purchase inputs in bulk at a reduced cost (see **Box I** for more on inputs access).

Access to markets solutions can provide an incentive for aggregators to reach otherwise informal or unorganized farmers. Access to market solutions may focus on supply chain management for aggregators through digital management systems, replacing paper-based systems. The World Bank lists key advantages to these technologies as enhanced connections to members, improved accounting and administration, and stronger collective voice and attendant political power.⁹ Additionally, several of the solutions in the assessment offer transparency in market relationships to prevent exploitation of smallholders. HelloTractor¹⁰ is an example of a market linkages solution providing access to inputs. HelloTractor allows farmers to rent tractors from owners for predetermined amount of time and also stacks functionalities to increase value for its customers: it is a booking agent platform, offers alerts for maintenance and technicians to service the tractor, and utilizes remote sensing to offer more in-depth analytics.



Access to Finance. Access to finance was commonly included on multi-service platforms, appearing most often after information sharing. Farmers are often excluded from formal financial institutions due to distance to financial service providers, lender's perceptions of farmers' creditworthiness, farmer's lack of formal collateral, and a lack of demand for financial products. While financial exclusion is not limited to agricultural value chains, the high degree of informality amongst producers and low levels of liquidity can explain its prevalence in the agricultural sector. The market for financial inclusion represents a largely untapped opportunity for financial institutions: some estimates suggest only 3% of the total demand for formal finance is met.¹¹

Digitizing financial transactions services provide new opportunities for farmers previously excluded from financial systems. As financial services are digitized, newly-collected data and analysis can provide new insights into farmers' financial behavior and serve as a basis for risk management by lenders. Mobile phones enable digital payments

Box I: Access to Inputs

Many ICT solutions that facilitate access to markets or finance also include a specific focus on providing farmers access to high-quality inputs. These inputs can include agronomic inputs like fertilizers and seeds, as well as a broader range of value-chain specific inputs, such as plant materials, farming veterinary services, artificial insemination, and/or farming equipment. These solutions are primarily targeted towards producers.

Over half of input access solutions were paired with information sharing platforms, specifically for farm management information services. This highlights that merely providing inputs without information or financing may have limited impact. Additionally, the service model for access to inputs still requires the physical delivery of a product to the producer, unlike information services applications and access to finance, which can be delivered digitally. This results in higher costs and risks for providers.

^c The FAO definition for markets and ICT includes pricing services, Virtual Trading Floors, Holistic trading services, downstream administration, and downstream management. The World Bank includes pricing services, improved logistics, supply chain management, and access to inputs. Sources: FAO, "ICT Uses for Inclusive Agricultural Value Chains" (Rome, 2013), <http://www.fao.org/docrep/017/aq078e/aq078e.pdf>; World Bank, "ICT in Agriculture: Connecting Smallholders to Knowledge, Networks, and Institutions" (Washington, D.C.: World Bank, 2017), <https://openknowledge.worldbank.org/handle/10986/27526>.

and can deposit money into digital savings accounts, which can then be used to build farmer financial histories and secure further access to credit. In agricultural value chains, farmer-aggregator relationships provide a rich data resource for farmer financial histories that can be used to create digital credit scores. Capturing this data in a way to fit financial institutions' needs can enable ICT solutions to develop partnerships that further extend financing to farmers. One company, FarmDrive, combines 'alternative data' with custom algorithms to build credit scores and connect farmers with financial service providers. FarmDrive incorporates datasets to assess the farmer's ability to pay, including agronomic and weather data, satellite imagery, and information on their social network. Their data collection methods include SMS-based surveys for farmer self-reporting on data that would otherwise be unavailable or costly to collect.



Tracking and Traceability (T&T). Just under 30% of ICT solutions offered tracking and traceability. ICT can lower transaction costs and improve supply chain traceability with different actors accruing various benefits across the value chain. Retailers and manufacturers may view fully-traceable supply chains as an opportunity to evidence provenance and assess farm practices for compliance to voluntary or mandatory standards. For aggregators and farmers, T&T can be utilized to compile individual farmer profiles, allow farmers to receive higher prices based on premium attributes, and facilitate information sharing. This could inform better adoption of production standards and certification by identifying farmers that are well-placed to pursue certification, streamlining accreditation procedures, and comprehensively tracking the impact of new farm management techniques on farm production and income.

Traceability is often confined to products for export markets.¹² This is corroborated by the assessment: of the 16 companies that offered tracking and traceability, 10 were targeted at exporters. While domestic markets may have less of a demand for traceability due to fewer standards, low enforcement, or low consumer demand for sustainable or certified products, the costs of coordination and integrating the systems could also prove prohibitive to implementation. Often, more advanced levels of T&T necessitate a shared protocol for tracking amongst value chain members via common software or interoperability between systems. In export markets, there is momentum for investments into improved traceability systems as multinational companies comply to new standards or seek to fulfill voluntary commitments for supply chain transparency and accountability regarding labor practices, human rights, deforestation, and other social and/or environmental criteria.

Improved quality assurance and control is a driving motivator for traceability solutions. Food waste, foodborne illness, food recalls, and fraud can all generate high costs for global businesses. Traceability solutions not only avoid these issues but can minimize the damage of future outbreaks by tracing to the source of contamination and having targeted recalls to impacted supply chain actors.¹³ Furthermore, the opportunity to utilize blockchain in traceability is generating interest, reflected in initiatives such as IBM and Wal-Mart's Blockchain for Food Safety Alliance in China that is seeking to develop a standardized method on food origin, safety, and authenticity on a blockchain platform.¹⁴ Blockchain technology drastically reduces the time to identify compromised products, in some cases lowering down the time to identify the point-source from weeks to seconds.¹⁵

4. Business Sustainability for ICT: Challenges and Use Cases

Despite the strong impact potential for ICT solutions targeted at farmers, many providers face significant challenges in maintaining financial viability. While there was not enough information collected to determine the average time of operations for solutions, the general perception is that many ICT services fail in their early years. There are several factors that contribute to a lack of long-term sustainability, including inherent design challenges for ICT-business models, difficulties in receiving support from donors and/or investors, and more fundamental problems in navigating impact-oriented but profit-driven business strategies. Given the variety of service offerings available and relatively young nature of the sector, it is unsurprising that there are few established and workable business models for ICT solutions with farmers as the primary beneficiary. Common challenges faced by these solutions include:

- Adopting and retaining users.** Retaining users and achieving scale are key to many ICT business models. In agricultural value chains that are composed of a high number of informal and often low-income or impoverished farmers, this challenge becomes more salient. There are many factors limiting farmer adoption of ICT services. First, the technology must offer a demonstrable value to farmers to make participation worth their effort. Next, even if the ICT does have a service offering for farmers, it is crucial that farmers are able to act on the new information or resources: farmers may require additional support or extension services to fully adopt the suggested practices. Last, target population demographics may limit adoption rates. Farmers are often an aging population with limited digital literacy, and their willingness to adopt ICT solutions may be lower than that of younger populations.



Figure 3 | **Agricultural Value Chains and Relevant ICT Services**

- **Charging for services.** The vast majority of companies in the assessment were early-stage or start-ups that focus on gaining scale and market traction. Companies must decide how much, when, and whom to charge for various services. This is relevant for services that do not deliver a physical product or finance but instead offer primarily digital or information-based services. Solutions that have valuable service offerings to farmers find it difficult to charge for their service, partially due to farmers and other agricultural value chain players being highly sensitive to price changes. Platforms serving multiple value chain actors often struggle to decide where and whom to charge: while farmers may gain the most from a given service, they generally have the lowest ability to pay. Additionally, it is important to consider flexible pricing models that align with agricultural production cycles: often farmers may value certain services more highly at different points in the season, and flexible cost structures that align to this may be more able to capture value from farmers.
- **Reaching scale.** Agricultural value chains are characterized by many actors and middlemen, meaning that any potential solution can cause unforeseen distributional effects. There is a high degree of decentralization, fragmentation, and inaccessibility amongst farming populations targeted by these solutions, which may increase marketing and distribution costs. Additionally, it has been found that many ICT companies potentially overextend themselves by adding a multitude of underdeveloped services onto their platforms before having established a viable core business model.¹⁶ This research did not look at when additional services were added to platforms or the motivation behind doing so, but it appears that many providers choose to add more services over time even without having an established and profitable business model.
- **Transferring ICT solutions across different value chains.** ICT start-ups will often focus initially on one or a few value chains yet will still define their addressable markets for the product across all agricultural commodities. However, there are inherent differences between value chains that can make it difficult to transfer one solution to another, whether that is a different commodity or even a different geographic region. The differences may include methods for collection, seasonal variations in production, heightened vulnerability to shocks, and varying standards and regulations.

To compensate for their lack of a viable revenue model, many ICT-start-ups rely on external partners or outside funding. However, donor-supported initiatives and publicly-led partnerships often fail after funding ends due to challenges in transitioning to a self-sustaining operation, especially if services are initially offered free of charge and later attempt to introduce fees.¹⁷ On the private side, successful and financially-viable examples of ICT start-ups in the agricultural space exist, yet a large share are unable to generate sufficient revenue and struggle to attract investment.

ICT start-ups will often participate in accelerator programs to secure further support.^d Accelerator programs and other non-commercial financing and networking programs, including the CSAI Project, can provide ICT start-ups the needed assistance and capital to overcome initial barriers to entry and achieve growth, in part through tapping into existing investor networks. However, a proliferation of ICT accelerator programs in countries like Kenya has led to a semi-competitive environment where programs vie to admit the same viable start-ups. In Kenya this leads to a perception of start-ups moving from one accelerator to the next without ever achieving full financial viability; also, a few ICT start-ups noted that the actual services provided by accelerators were of varied or even limited use, and the main attraction for participation was the investor network. A general perception amongst some accelerator programs was that too few start-ups were able to meet investors' criteria to secure investment, even after acceleration. Often, the accelerators are general or offer sector specific (i.e., agriculture) or technology-specific programs but not both. This limits the value of accelerator support for ICT in agriculture services.

^d This section was informed by formal and informal conversations with several accelerator managers and ICT start-ups in Kenya during April 2018.

Box 2: Challenges Reaching Scale with Information Sharing Services

Charging for Services: Information Sharing Platforms have two primary revenue models: subscription or on-demand payments. The World Bank has previously found that on-demand services and payment may be better suited for user retention¹⁸ while subscription services must discover the right price point to attract and retain users. Furthermore, most farmers do not have a stable source of income and/or liquidity and have short investment horizons. This means farmers may have a fluctuating willingness to pay that corresponds to the growing cycle. Charging flat rates, either through subscription or on-demand, may lead to lower retention in periods when farmers experience high costs and low income.

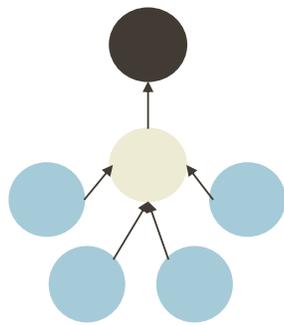
Balancing User Retention and Revenue: Information Service platforms are the least expensive of all the service solutions as it is possible to leverage existing mobile phone infrastructure and require relatively low capital costs. However, it is arguably the least valuable service without additional investments. This can be in delivering tailored, timely, and relevant content delivered farmers,¹⁹ or by offering complementary services that allow farmers to utilize the information they receive. These investments drive up costs for the provider but may improve user retention. For example, local-language voice messages may be the most effective means of communication but require additional labor and reduces the speed products can be deployed.²⁰

Challenges with Adoption: While using ICT to deliver content greatly expands the population able to receive the information, the gulf between accessing information and adoption of the practices presents challenges. Content should be actionable in order to allow farmers to see the value and benefits of the service. Subsequent actions need to be realistic for a farmer to take: the proposed information cannot be too expensive, too advanced without training, or require high time/labor costs without explaining the benefits. For example, farm management best practices may need to be paired with trainings, demonstrations, or follow up. To increase adoption and reach scale, possible solutions can include providing flexible payment/subscription options²¹ or offering financing or reduced-cost services for farmers.

Many of the challenges presented are more likely to affect services that target smallholders in informal and disaggregated supply chains. Two case studies are presented below to highlight the opportunities and impact of integrating ICT solutions into more integrated and formal value chains. These ICT services may not directly target farmers, but upstream companies can channel improvements in yield, income, and market access to farmers within their supply chains through the integration of enhanced data and improved market linkages. These ICT improvements can hasten the transition towards sustainable business models and ensure a sustainable supply of agricultural commodities. Further research needs include how technology beyond ICT may be used to further benefit farmers, as well as more research into the long-term benefits (financial, operational, and risk mitigation) accrued by organizations that pursue novel technology-enabled business models focused on farmer impact.

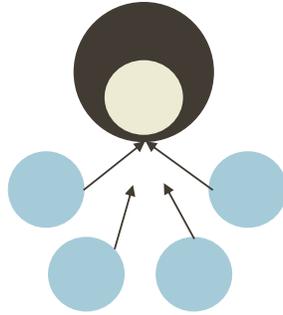
Case Study 1: Investing in Data Analytics

ICT solutions often do not utilize full information analytics functionality. Many ICT solution providers have access to detailed information on their users but may be unaware of how to best analyze it and derive intelligence that can be used to improve or expand service offerings, packaged in a way that is attractive to potential partners, and monetized. Investments in analytics can therefore both serve to improve internal processes and own service offerings or to make intelligence available to third parties. The value of the intelligence to this party depends on the degree to which it provides actionable information on other actors in the value chain including potential customers. The ability to monetize this data rests on the provider's ability to develop a viable revenue model, for example by providing access to analyzed information and intelligence on a licensing or subscription basis. ICT solutions that successfully monetize data tend to rely on a business model that includes downstream users of the data that pay for access. Without a clear opportunity to monetize data, investments in infrastructure and processes to deliver usable data are not regarded a priority for providers. **Figure 4** presents a range of business models relating to data analytics.



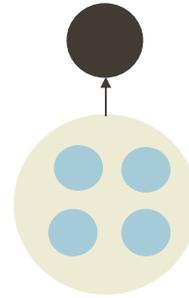
Analytics provider sources, aggregates, analyzes data and sells as one-time product or ongoing service to partner

Very High Prevalence



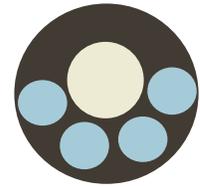
Partner has in-house analytics capacity and models, but accesses or buys data from other players

High Prevalence



Data is generated at the source, builds own analytics capacity or has a close partnership with analytics provider, sells to partner

Low Prevalence



Same entity collects, analyzes, and uses the data.

Low Prevalence



Partner: supply chain partner, financial institution, gov. partner, etc.



Analytics Provider: ICT Company, value chain company, etc.



Data Generator: farmer, cooperative, etc.

Figure 4 | Types of Data Arrangements

Adapted from: Initiative for Smallholder Finance, briefing 11, “How Big Data and Data Science are Changing Smallholder Finance,” Figure: Archetypes of alternative data-based models

Data-sharing arrangements among value chain partners can reduce uncertainty and justify investment into information analytics processes. Often there is a pre-identified purchaser or partner that is willing to use the analyzed data that helps a provider justify investment in necessary analytics infrastructure. As **Figure 4** demonstrates, 3 out of the 4 models for data sharing include an external partner. For ICT, this is most often achieved through partnerships with financial institutions or downstream value chain actors. Retailers, especially those in export markets, have an interest in provenance and may pay for farmer information. However, if data analytics is part of the business model from the start, then it can be the foundation for greater ICT-service layering and enable more sophisticated targeting of integrated services such as information sharing, access to market and access to inputs.

The value of data changes according to its validity, reliability, and consistency, and the types of users interested in the data. Disparate systems for data collection and analysis can compromise the interoperability or integration of data collected across systems, especially if processes are set without cohesion for timelines, types and depth of data recorded, and if actors have divergent methods for data collection. Data quality suffers when information is self-reported, which is the case with many applications due to the high cost of primary data collection. The Sustainable Trade Initiative (IDH) notes that data diversity can be a key challenge for industry-wide initiatives, in particularly as it relates to consistency of data and the reliability of data across companies’ various data collection methods.²²

Data-sharing can be a core component of business models at an early-stage to drive collaboration and maximize the benefits and value of data collection and analysis. In the cocoa sector, the IDH illustrates how several industry-wide initiatives to establish protocols and methodologies to encourage the uptake of standardized and proven approaches to data reporting, collection can unlock further collaboration and impact.²³ Partnering and sharing data with non-profit or government actors can also inform more rigorous policy and support development of improved public services to various value chain actors.

Box 3: Internal and External Data-Sharing Arrangements

Happy Cow, Ltd. (HC) is a family-owned milk processor of cheese and yoghurts. It sources raw milk from three smallholder cooperatives and, with SNV Kenya, has introduced a *Quality-Based Milk Payments (QBMP)* system for their farmers. The program centers on a *tracking & traceability system (T&T)* that connects milk production back to its original farm and pays a premium price for higher-quality product. Eventually, farmers that fail to meet standards will be penalized by receiving lower payments.

As part of the system, HC has *implemented a comprehensive system of data collection and analysis*. Through this system, HC can identify producers that consistently provide high-quality milk, analyze their farm management methods, and develops tailored technical assistance recommendations. These recommendations are shared with upstream cooperatives, who in turn can provide the needed improvements to their producers.

While it has not yet been measured, Happy Cow anticipates increased savings through reduced production costs. In the longer term, Happy Cow will increase their earnings by selling higher-quality processed goods. This differentiated product could gain higher prices and enter into higher-value markets including export. Both these factors, improved revenue and lower costs, are expected to finance the QBMP system.

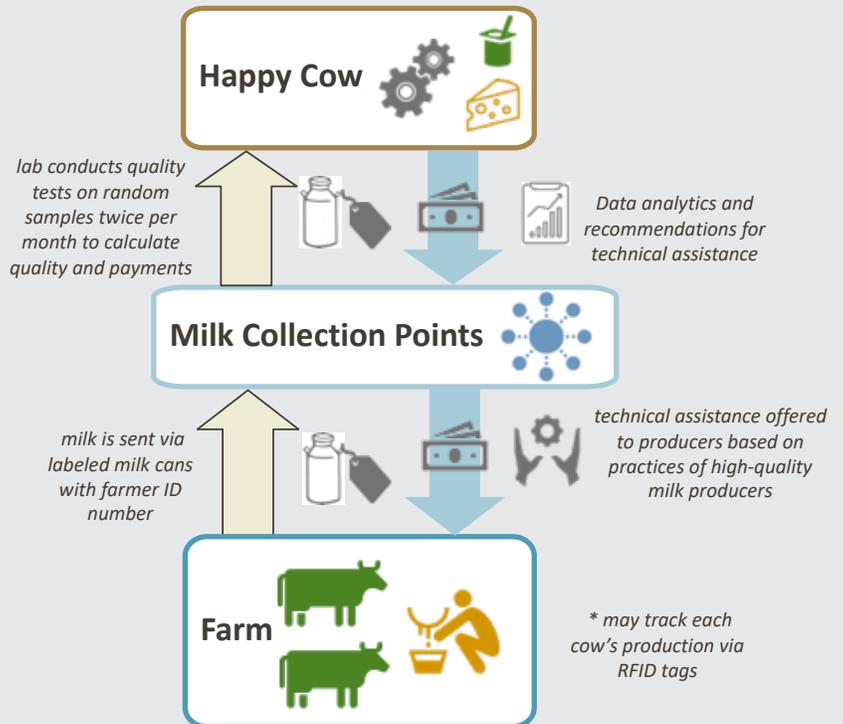
Happy Cow has seen improvements in the quality of their supplied milk, but a majority is still not meeting current quality standards. Happy Cow is cooperating with the Kenyan Dairy Board (KDB) to share the results of their QBMP system and related data-sharing arrangements as the KDB develops its next strategy for engagement with the sector and to pinpoint areas of improvement for the sector as a whole. While Happy Cow is not selling their data, the processor is using in-depth analytics and partnerships with downstream actors for improved production, higher quality, reduced costs, and higher earnings.

Sources:

Ndungu, Teresia. "Implementation of a Quality-Based Milk Payment (QBMP) System in Kenya." presented at the 13th African Dairy Conference & Exhibition, Johannesburg, South Africa, November 26, 2017.

Rademaker, Ida F., Anton Jansen, Reuben K. Koech, and Jan van der Lee. "Smallholder Dairy Value Chain Interventions." The Kenya Market-Led Dairy Programme (KMDP) - Status Report. Wageningen UR Centre for Development Innovation, June 2016.

This section was also formed with conversations that took place in Kenya in April 2017 with part of Happy Cow's ICT team.



Smaller start-ups often perceive significant risks in sharing or monetizing their data which together with upfront development costs can pose a barrier to maximizing data utility. Monetizing data leaves companies vulnerable to privacy issues and regulatory challenges and present an implicit barrier. Companies holding financial records of farmers or traders often perceive additional risks when seeking out partners. Financial institutions have stringent regulations to "Know Your Customer" (KYC) and other privacy regulations that provide useful input but are yet to be systematically applied in many ICT solutions.

Case Study 2: Blockchain for Tracking & Traceability in Supply Chains

Blockchain-based systems have the potential to create new business models for supply chain management systems. At its basic level and in the right context, blockchain technology provides a digital, decentralized, and distributed ledger that allows various actors to interact with, input, receive, and access the same information upon a technological backbone that makes rule-breaking, hacking, cheating, and dishonesty exceedingly difficult to almost impossible. As such, it offers novel approaches primarily for tracking and traceability based on its information management, contract execution, and decentralized governance structure. The FAO defined three key

parameters in which ICT could lower current transaction costs and improve the uptake of traceability solutions, all of which are fulfilled by blockchain technology (See **Box 4**):

- 1) *Systems orientation* in which all documents are issued through interaction with the software
- 2) *The ability to review* that all previous steps are completed and to track the movement of documentation and products
- 3) *Built-in checks and balances* in the software to ensure that previous steps are completed before the next step in the process takes place.²⁴

Tracking and traceability needs vary across supply chains and contexts, require high degrees of coordination, and can entail high costs. End-to-end tracking and traceability depends on harmonized data collection from every supply chain actor, from producer to retailer. This seamless connection can occur in one of two ways: either every actor inputs data into a uniform, centralized platform; or multiple systems must be synced to stitch together an unbroken record of product movement. The costs of traceability are higher in fragmented supply chains and commodities have different tracking requirements, further underlining the need for coordination among supply chain participants and the development of common practices or standards for companies to follow.²⁶ Several factors should be considered before integrating blockchain into T&T:

- **Some supply chains are more suited to other technologies.**²⁷ Given the requirements for coordination, T&T through blockchain would be difficult and expensive to apply to highly informal or disaggregated supply chains. Conversely, highly centralized or integrated supply chains with few stakeholders may find more use in centralized database systems. Export-oriented agricultural supply chains may be most applicable given their largely decentralized structures, a need to store/transfer data across multiple organizations across the value chain, increasing consumer demand for provenance information on products, and existing information asymmetries that imply a need for greater trust amongst actors.
- **Verification systems or processes for data collection and processing need to ensure high-quality information is entered into the system.**²⁸ While governance protocols can be put in place to remedy false or mistaken information into the blockchain, some tracking technologies can be duplicated or tampered with, limiting their authenticity,²⁹ and group of actors/regulators can collude to allow false information to be put onto the blockchain. While the Internet of Things (IoT) and smart contracts can limit this risk, those systems will entail higher initial costs. Robust verification frameworks should be envisioned for all actors that are able to input information onto the system.

Box 4: Overview of Blockchain's Key Capabilities and Related Technical Aspects²⁵

Decentralized Governance: Blockchain and other distributed-ledger technologies operate as peer-to-peer networks in which new information must be verified through predetermined processes (i.e., a consensus mechanism) to be stored, recorded, and exchanged.

Simultaneous and Verified Updates: Once information is approved by the consensus mechanism and transcribed, all blockchains belonging to permissioned actors are updated simultaneously and cannot be edited. Each block of information is assigned a unique hash which is in part determined by previous information: ^c tampering with earlier information alters the block's hash and has a ripple effect that invalidates it and all later information (as an altered hash and its subsequent variations are not verified). This allows for integrity of information on the blockchain and prevents tampering and hacking.

Transparency and Accountability: The decentralized governance and simultaneous and verified updates allows for immutable, consensus-based additions with distributed access points and real-time updates, effectively eliminating information asymmetries while offering transparency and built-in accountability. Furthermore, transactions can be automatically executed once predetermined qualifications are fulfilled, allowing for "smart contracts" amongst participants. Smart contracts can digitally execute pre-defined transactions once agreed-upon conditions have been fulfilled. This minimizes default on contracts and can help improve accountability.

- **Blockchain operates on a network effect, meaning it is most effective once scale is achieved.**³⁰ There is also a need to fully transition every actor across a supply chain to a new system, which can pose high transaction costs that prove insurmountable to diffuse, disaggregated, or informal value chains and supply chains. The following section explores some of the difficulties that ICT solutions, including blockchain, face when attempting to reach sustainability.

Blockchain can be integrated into existing certification T&T systems to lower costs, increase efficiency, and enable broader uptake. Blockchain and other advanced technologies can be embedded within existing tracking and traceability systems to support the sustainable transformation of supply chains (See **Box 5** for an example of a pilot). The needs of global transport and supply chain logistics often requires the bulking of products from various sources. Currently, there are three traceability models used to identify products that fit certain sustainability and certification standards: product segregation, mass balance, and book and claim³¹ (See **Table 2**).

Model	Characteristics
Product Segregation	Bulking: Separates certified from non-certified production; allows for certified production from different sources to mix Identity Preservation: Maintains full segregation of certified production from all other products, including certified products from different production sites
Mass Balance	Certified and non-certified products mix; exact volume of certified production is known and only that percentage can be marketed as certified to end users. Implication is that end products may have all, some, or no certified production
Book and Claim	Certified and non-certified production mixes. Companies with certified production are awarded certificates that can then be traded. Non-certified companies can then purchase certificates and claim to “support sustainable sourcing/production” while the product itself is not composed of certified materials

Table 2 | *Supply Chain Traceability Models for Certification*

Product segregation requires the physical separation of certified and non-certified materials. *Identity preservation* requires the highest degree of monitoring, reporting, and verification throughout the supply chain. This system is often used for consumer-facing products with clear quality or other differences between the sustainable supply and the unsustainable supply,³² and where these differentiated products will likely gain preferential market access, higher price premiums, or larger market share.³³ This is the only proven method to establish full traceability of products to their original farm, forest, or production site.³⁴ *Segregation* or *bulking*, the second model within product segregation, also requires the physical segregation of certified and non-certified materials but allows for certified materials from different sources to mix. This does not have full traceability, and end products may be composed of a mix of certified and uncertified production.

Blockchain may reduce the costs associated with segregation models. A recent Deloitte report on the IoT and blockchain explores how several layers of integrated technology could ensure full identity preservation: a tracker (RFID code, bar code, QR code, etc.) physically attached to each product (crate, pallet, bag, etc.); sensors/beacons that identify when those trackers are moved; and networked software systems to collect and present the information.³⁵ With a verifiable digital record of the products’ point of origin and certification status stored on a blockchain, products could be uniquely identified in a digital channel as they travel through traditional supply channels. Additionally, product segregation models are only possible on decentralized supply infrastructure models.³⁶

“Smart” contracts could enable the automation of certain procedures, further driving down costs. In effect, physical movement of production through a supply chain could trigger automatic alerts, payments, verification, and ongoing tracking updates in a digital system that pre-defined actors have access to and interact with. Utilizing a blockchain can allow permissioned actors to access troves of information and data across the value chain that may have

previously been unavailable to them, allowing for greater benefits to accrue from enhanced transparency. These factors can lower costs for tracking and traceability along every step of the supply chain, a key factor in fully segregated models.

Mass balance and book and claim models allow for the mixing of certified and non-certified sources but require ongoing monitoring from centralized sources. At each point in the supply chain, a certification agency must monitor, verify, and reconcile production flows to ensure that the number of certified products purchased downstream is equal to the volume of the resource base that is sold upstream.³⁷ Book and claim models do not require monitoring after certified producers receive their certificate to sell on global trading platforms. While these platforms allow downstream users to purchase certificates and make certain sustainability claims, they nevertheless have a higher risk of fraud and unclear institutional responsibilities that compromises trust and effectiveness.³⁸

Mass balance and book and claim systems may not be as readily transferable to blockchain. Both systems require a centralized authority to oversee supply chain activity and verify that sustainable practices are occurring.

Monitoring is tied to transaction-based information^e that is easier to monitor than tracking physical product flow, meaning blockchain systems may have high costs for too few benefits. Book and claim models, such as the Roundtable on Sustainable Palm Oil, operate through database systems that already have centralized authorities in place to monitor the activity that takes place, limiting the value-add of decentralized solutions.

Blockchain-based systems are not immune to unintended consequences. As explored in a recent paper,⁴⁰ any initiative to improve supply chain transparency with an aim to improve sustainability must ensure that greater transparency does not exacerbate existing power imbalances or remain inaccessible to farmers or other vital value chain actors; more information should lead to greater investment and support into sustainable practices as opposed to diverting resources away from non-compliant farmers. Blockchain technologies alone cannot achieve this, but the accountability and transparency must be designed into the underlying infrastructure.

Box 5: *Blockchain for Sustainable Tea*

One blockchain pilot is seeking to demonstrate how tracking and traceability may ensure more sustainable production and higher incomes for farmers.³⁹ In a project led by the University Cambridge Institute for Sustainability Leadership (CISL) and a consortium including Unilever and Sainsbury, a blockchain-based system is set to track the origins of tea and wood products as they travel from up to 10,000 farmers in Malawi to Sainsbury and Unilever. By verifying the sustainable sourcing of their tea and wood products, the two global companies are intending to reach 100% sustainable sourcing of agricultural products. If successful, the pilot will also include several financial institutions that plan to deliver preferential finance to farmers that have committed, and have demonstrated through the blockchain, to consistently supply sustainable production.

While the exact nature of the system is not provided, the four technology start-ups involved provide insight into how sustainable sourcing will be verified: the FOCAFET Foundation, Halotrade, Landmapp (now Meridia), and Provenance offer blockchain solutions for open source identification data, ethical supplier finance, digital land rights documentation, and tracking and product origination.

FOCAFET Foundation – <https://focafet.org/>

Halotrade – <http://halotrade.io/>

Meridia – <http://www.meridia.land/>

Provenance - <https://www.provenance.org/>

5. Supporting Farmer-Oriented ICT Solutions

Presently, ICT solutions providers have limited ability to scale their solutions despite high social, environmental, and other public benefits or impacts. Many of the benefits outlined in this brief can be defined as public or even market benefits without a sole, clear beneficiary. The common inability of ICT solutions to achieve scale or financial sustainability without external support prevents target populations from enjoying the full scope of these benefits. Start-ups tend to struggle in turning benefits provided by their solutions into concrete services that can be

^e For an overview of the six types of information that can be integrated on tracking and traceability systems, see: Gardner, T.A., et al., “Transparency and Sustainability in global commodity supply chains,” World Development, 2018. <https://www.sciencedirect.com/science/article/pii/S0305750X18301736>

monetized. As demonstrated, even those companies that do charge for their services often face low willingness or ability to pay from their target beneficiaries. The tension between a need to generate revenues and expand impact can limit the achievement of either.

Measuring the full scale of their impact is difficult and costly for businesses. Impacts achieved by ICT solutions can be diffuse, multifaceted, and difficult to measure, resulting in high-costs of conducting impact assessments or other ongoing monitoring and reporting. Additionally, businesses are unlikely to receive direct monetary benefits from measuring this impact without additional support mechanisms. For large companies that have integrated ICT into their individual supply chains, they may not publicly release the full extent of their findings. As a result, the exact nature of the impact of ICT on supply chains is largely unmeasured.

Additional public and private support is needed to grow the market for ICT in agricultural value chains. This can be through the offering of incentives for developing ICT solutions for agriculture or enabling more direct investment pathways for private sector investors. It is important that these incentives are tied to strong criteria relating to performance – there needs to be a greater understanding of the advantages and disadvantages for different ICT for agricultural business models across the types services being offered. Effective public policies and incentives can allow the positive impact provided by ICT in agricultural solutions to be nurtured while ensuring that agricultural value chains and communities are receiving the full scope of benefits provided. Private engagement and investment can support the development of more sustainable business models and provide a source of capital to guarantee financial sustainability.

Public Policies to Incentivize Impact

In Kenya, the Blockchain and AI Task Force ran an open call for presentations to present how these technologies could be applied to President Kenyatta's Big Four Agenda. While there were no incentives tied to the presentations other than the chance to influence policy regarding the topics, the Task Force nevertheless received over 200 applications for presentations. Many presentations focused on improved food security, including use cases addressing how to increase the value attained by the farmers. At the early stage of recommendations, the Task Force was exploring potential ideas relating to promoting decentralization hubs outside of Nairobi and creating an Innovation Fund or SACCO to finance the necessary infrastructure or human capital.⁴¹ These incentives can also act as a form of regulation by setting certain standards for their provision, such as oversight or regulation on the types of data that can be shared, or the quality, consistency, or accuracy of information being sent to farmers.⁴² For climate-smart agriculture (CSA), further research is needed to understand how farm management information services have integrated CSA.

Targeted incentives, grants, or assistance can further enable sustainability of ICT businesses. Reports by the FAO and the World Bank focus on the role of government for supporting the infrastructure requirements of ICT and/or agriculture sectors, such as ensuring the expansion of national power grids, expanding telecom and internet infrastructure, and investments in irrigation and roads in addition to other wide-scale infrastructure investments. Additional indirect support for ICT and agriculture can be the establishment of national training programs for improving the digital literacy of farmers, scholarships or funding for programming or computer science courses in universities, and promoting the improvement of existing accelerator programs. Other opportunities could be offering grants or support to improve the impact metrics of ICT businesses in agricultural value chains; not only will this help to quantify the benefits that communities are receiving, but it can help to develop further policy support programs. Support should be highly targeted and have a clear pathway to company's independence from grants in the short to medium term.

Allowing for the registration of alternative business models with specialized incentives in place could help to engender impact and facilitate government support. Registering as alternative businesses, such as social enterprises, may help to unlock the full extent of the value already offered by many ICT start-ups. Several countries recognize social enterprises or similar organizations as legal entities and provide benefits, such as tax benefits, eligibility

for government programs or grants, and exceptions to certain duties and fees. Once these organizations are recognized as legal entities, then it will be easier to confer incentives and benefits to them and their beneficiaries to expand impact.

Private Investment Landscape

ICT solutions in agriculture including blockchain technology are a hot topic and bring new types of investors to the table. As discussed in this brief, ICT solutions have the potential to overcome many of the challenges in agriculture and therefore have significant growth potential. From an investor perspective, ICT can be more appealing than traditional agricultural investment as it promises a technology solution that many investors are more familiar with, tends to be comparatively asset light, potentially rapidly scalable, and seemingly easier to exit through strategic sales. ICT solutions have the potential to attract technology focused investors that may not have been exposed to agriculture.

Another positive signal is an increasing interest by impact investors to invest in Africa, signaling an opportunity to grow agriculture as an investible asset class. In 2016, it is estimated that Africa represented 19% of all impact investment assets under management, with many investors intending to increase their investments for 2017.⁴³ Impact investors represent a diverse set of actors with varying criteria for disbursing finance, including divergent beliefs on how to balance risk, return, and impact in investment decisions. Impact investors often target businesses with a high potential to reach scale⁴⁴ - a chronic challenge in agriculture - which further explains why ICT solutions are receiving increasing attention.

Research on current investment volumes in ICT in emerging markets is limited. Research on “AgTech” and “AgriFood Tech” (fields of investment including the ICT services discussed in this assessment (See **Figure 5**)), suggests that the vast majority of investment continues to be realized in developed countries with a focus on fewer but larger deals. The investment landscape for AgriFood tech, as of 2017, was characterized by an increase in financing volumes but a decline in the number of deals; deals targeting mostly downstream rather than upstream actors; and a 28% decline in seed stage deals.⁴⁵ Investments are highly concentrated in more mature markets: while historically centered in the US and the EU, only Brazil and Argentina are emerging as serious investment destinations in the Global South. Of the AgTech categories, Supply Chain technologies (also called “midstream technologies”) represented 9% of all investments, coming in third of all the AgriFood categories.⁴⁶ The comparatively small representation of ICT solutions in emerging markets is due both to the much larger investments in agricultural technology and machinery in developed countries, as well as the much smaller size and early-stage nature of investment in ICT solutions in the Global South themselves. While it is unlikely that investment volumes in ICT in emerging markets will be able to match AgTech or AgriFood Tech investments in developing countries in the short-term, there is significant potential to attract investment if ICT solutions providers can deliver on their promise to reach scale and deliver sizable deals.

ICT solutions that provide access to finance may serve as an entry point for impact investors to enter the ICT for agriculture space in Africa. In 2017, a Global Impact Investment Network survey found that financial services and food and agriculture were viewed as key sectors for current and future investment,⁴⁷ while investment into ICT was projected to decrease.⁴⁸ Another survey found that a majority of firms expected to increase their investment

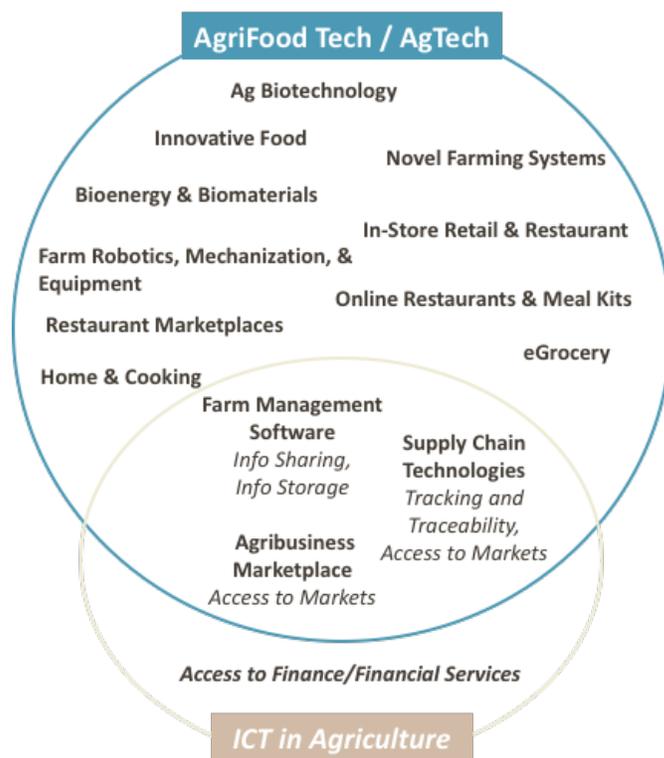


Figure 5 | AgTech vs. ICT in Agriculture

into financial tech (“FinTech”) for 2018,⁴⁹ yet KPMG found that the \$8 billion worth of deals for FinTech in 2017 was largely concentrated in markets like the US and Europe.⁵⁰ Of the investment funds raised by African start-ups in 2017, most of the funding, nearly a third, went towards FinTech.⁵¹ In 2018, the AgTech sector saw more firms entering the market than in 2016 and 2017, gaining roughly \$19 million worth of investment.⁵² Since many of these latter ICT solutions are likely to include a finance component, investors may leverage their FinTech experience to invest in ICT for agriculture.

ICT solutions can address inefficiencies in agricultural value chains but are not removed from or immune to complex challenges of agricultural production and investment. While investors may prefer fully digital solutions that are relatively hands-off regarding physical handling of inputs or agricultural products, such solutions are harder to find and tend to have a lesser impact in transforming value chains directly. Investors interested in ICT in agricultural therefore need to accept residual risk of operating in highly fragmented and opaque markets. Many risk-return frameworks are fundamentally incompatible with the needs of the sector; often, their willingness to accept the risk for transforming agriculture at the farm level is too low, and their expectations for return and ease of exiting are too high. While publicly provided instruments such as first-loss capital or full or partial guarantees can help to mitigate risk, unrealistic return expectations cause investors to seek out investments that may be too large compared to the actual capital needs of firms or too disconnected from the farm level to deliver true impact. If investment in ICT solutions and agriculture in general is to be increased, fund structures and investor mandates may have to evolve.

DISCLAIMER

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