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Digital solutions for agricultural value chains in Kenya: the role of private-sector actors

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1. Introduction

In recent years there has been much discussion about 'digital transformation' in the agrifood system [1] and its role in enabling climate resilient development [2]. Given the lack of clear and compelling data to connect these two trends, this issue brief examines the gap between the rhetoric and reality regarding the current role and importance of digital solutions for agricultural value chains in Africa, including those that can be termed 'climate smart', with a focus on the role of the private-sector in the development and diffusion of these solutions. As such, this brief is focused on analysing the market for digital technologies, used specifically in the Kenyan agricultural sector, rather than exploring the impacts (on markets and production systems) of these technologies per se. It is based on a pilot study from Kenya carried out in 2021 (see Annex 1).

Broadly defined, agriculture is a major economic sector in Kenya, directly accounting for 26% of GDP and contributing a further 27% of GDP indirectly, through linkages with other sectors. Agriculture employs more than 40% of the total population in Kenya and more than 70% in rural areas [3], while agri-food exports account for 65% of export revenues [4].

Climate change is projected to significantly affect agriculture, food security, water resources, natural ecosystems and economic stability all over the world and especially in the Global South including in Africa, where climate change poses a particular risk to smallholder farmers, due to rising temperatures and shifting rainfall patterns. In Kenya, agriculture is also one of the sectors most exposed to climate change risk. With low rates of irrigation, the majority of agricultural production relies on seasonal rains, exposing the sector to the short-term risk of crop failures and long-term production declines due to changing climatic conditions. [4,5].

Kenya is a forerunner within Africa in the use of information and communication technologies (ICTs) and has more digital-for-agriculture (D4Ag) enterprises and users than any other country in Sub-Saharan Africa, with over 100 solutions on the market [6]. Kenya therefore provides a relevant case for examining the nature, current status and future opportunities for digital solutions for agricultural value chains, in Kenya and for other parts of Africa.

This issue brief presents preliminary results from interviews with experts and firms operating in this space, to provide 1) an overview and status of the opportunities regarding digitalisation in Africa; 2) a summary of the relationship between climate change and digitalisation in the African agricultural sector; 3) insights from the agricultural ICT market in Kenya, with a focus on the firms in operation, their technologies and services, and business models.

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2. Digitalisation in Africa: status and opportunities

The digitalisation of economic activity through technologies such as ICT, Internet of Things (IoT), Artificial Intelligence (AI) and robotics in production and service provision can be a strong driver of sustainable and inclusive growth and innovation to achieve the SDGs in Africa and other parts of the Global South. Digitalisation can even be seen as the key factor in an alternative, service-based industrialisation strategy for Africa, the so-called 'servicification of manufacturing' pathway characterised by 'industries without smokestacks' [7]. The responses to COVID-19, in particular the need for social distancing and more agile supply chains, have further revealed the necessity and benefits of harnessing digital technologies for improving productivity in areas such as mobility, agricultural advisory services, food provision, finance and health.

Conversely, a failure to harness the opportunities offered by the digital economy is likely to result in economic stagnation, increased inequality, unsustainable development, exposure to risks such as the COVID-19 pandemic, and a widening of the digital divide vis-à-vis the rest of the world. Digitalisation is a strong trend across much of Africa, but the digital economy is still relatively small and limited to a few areas such as usage of feature mobile phones and related USSD-mediated[1] services within personal transport, payments/banking, and price information. Nevertheless, the "mobile economy" accounted for 6.7% of the overall GDP in Africa in 2016, representing US$ 153 billion. This was forecast to reach 7.6% (US$ 214 billion) of the overall African GDP by 2020 [8].

In Africa, services based on digital technologies target mainly urban consumers, but they are also used for payment and monitoring in rural energy instillations (solar home systems and mini-grids), and in the agricultural sector, as this brief shows. Despite increasing adoption, Africa has the lowest rate of smartphone ownership of any geographic region [9], and the use of digital technologies in the productive sectors and in the public sector is only starting to emerge.

A number of factors account for the low diffusion of digital technologies in Africa. A key barrier inhibiting the spread of multiple technologies is low internet connectivity, with a band width that is 20 times lower, on average, in Africa than in Europe. Additional factors include high prices of services and equipment relative to incomes, low (digital) literacy levels, lack of advanced skills among the work force, limited capabilities of firms (mainly SMEs and start-ups) and low relevance of the digital services provided. These factors are compounded by an unconducive regulatory framework, a weak and/or underfinanced public sector, and the high cost of investment finance, among others.

At the same time, numerous private, civic and public organisations are engaged in activities aimed at developing and enabling the digital economy and many of these are directly relevant to the SDGs. They include research, development and demonstration projects as well as commercial-stage activities related to technologies, products, and services in a number of sectors or application areas. This includes the food and agriculture sector, where digitalisation enable the provision of important services to value-chain actors, which can be categorised as follows:

- farm advisory and information services (weather forecasts, agronomy, storage etc., including agricultural data hubs providing weather forecasts and agronomic data to other service providers),
- services providing market information and linkages (price information, access to input and output traders and markets, etc.),
- supply chain management services (product traceability and quality assurance, enterprise resource planning, contract-farming scheme operation, etc.),
- financial management services (mobile payments and savings, access to credit, crowdfunding for investment projects, digital credit assessment).

We henceforth collectively refer to these as 'agriculture ICT services'. We note that the ICT services supplied by private firms or other actors are based on digital solutions (technologies or products) but include also critical activities such as data management, customization, maintenance, etc.; hence the use of the term 'service'.

[1] Unstructured Supplementary Service Data (USSD) is a Global System for Mobile Communications (GSM) protocol that is used to send text messages. USSD applications run on the network, not on a user's device. As such, they don't have to be installed on the user's phone, which is an advantage for users with feature phones that have limited storage space. Source: [17]

3. Climate change and digitalisation in the African agricultural sector

Some of the effects of rising global temperatures such as heat waves, changing precipitation regimes and cyclones are already evident in many developing countries where smallholder farmers' ability to cope with climate change is affected by limited adaptation capacity with few alternative sources of income, lack of expertise and training as well as insufficient support from political institutions [10]. Accelerated climate change is making year-to-year weather variability exceedingly challenging for farmers as it forces them to make management decisions before they know how exactly climate variability will unfold that particular year, creating possible income losses. Especially risk-averse farmers are experiencing the burden of climate uncertainty [6].

Kenya is already experiencing high inter-annual variability of precipitation, causing droughts and floods in both the arid and semi-arid lands and key agricultural zones [4]. In addition, there are indirect impacts, in particular increased rates of surface water runoff and soil erosion and the risk of crop losses from wildlife migrations and rising and novel infestations from insects, diseases and weeds attributed to climate change [4].

In the context of these climate risks, it is believed that ICTs can significantly increase the speed of receiving and distributing data, updates and information in relation to weather situations. As such, ICTs offer a unique opportunity for farmers to cope with and adapt to climatic change and to improve farm management in general [11]. These benefits (real or potential) means that applications of ICT in agriculture, such as weather and climate services, have been increasing over the last decades. According to some observers, these technologies have proven to be a powerful tool to enhance farmers' adaptive coping abilities and increase strategic management in agriculture [12].

Specifically, the provision of climate forecasts can potentially enhance farmers' adaptive capacity and so reduce their vulnerability to climate extremes and at the same time make opportunities available [13]. For example, in Senegal seasonal forecasts induced changes in the farming practices in almost 75% of the cases [13]. Still, farmers experience several obstacles when using seasonal forecasting systems: the accuracy of the forecasts are insufficient as they are often based purely on theoretical models, they lack supporting decision-making tools, and they do not take account of farmer behaviour. This results in farmers knowing about forecast services without using them [6,14].

The issues and opportunities outlined above informed the methodology (Annex 1) that guided the pilot study of the Kenyan agriculture ICT market reported on in this brief. The next section presents the key findings of this study.

4. The market for agriculture ICT services in Kenya

4.1 Actors supplying or demanding ICT services

It is widely agreed that ICT services can play a crucial role in bridging knowledge gaps for value-chain actors in Kenyan agriculture, and so there is likely to be a continued demand for them [int. 3].[2] At the same time, although mobile reception in Kenya is generally poor, the majority of the country, including rural areas [int. 2], has some mobile network coverage and almost all farmers own a feature mobile phone, while fewer own a smartphone.

In this context, the development of ICTs for agriculture has seen an explosive growth across the whole value chain over the past several years, with over 100 ICT solutions available on the market of which 64 were headquartered in Kenya [2]. The development of new ICT solutions continues, despite the fact that the initial hype around the potential of ICT in agriculture has died down as many of these products and services have, according to one source, failed to deliver especially in terms of any real change to agricultural practices [int. 3].

A variety of actors supplying or demanding ICT services were identified by this study:

Numerous ICT SMEs and start-ups have emerged in the region in response to the business opportunities offered by digitalisation and a few (e.g. eProd, Twiga and Esoko) have been able to scale up to medium-sized or large companies.

Incumbent firms, notably regional mobile network providers (e.g. Safaricom) and international IT firms have provided physical infrastructures (e.g. MTN and Airtel, Google/Loon), platform technologies (e.g. FB and WhatsApp groups), or engaged directly in service provision (Uber, Bolt). Established banks and insurance companies have been central for the integration of ICTs with financial services (mobile payment services, micro credit, crop and weather insurance).

Agribusinesses such as produce aggregators, commodity exporters, contract-farming scheme operators, and dairies have been an important source of demand for ICT solutions within supply chain management and digital payments.

In addition, government agencies and institutions have developed policies, regulations, innovation labs, R&D activities etc. in an attempt to create an enabling environment for digitalisation, often assisted by technical and financial donor support, e.g. from USAID, SNV, GIZ and the World Bank.

Table 1 below lists selected firms and projects that provide agriculture ICT services in Kenya today, alongside the type of service delivered, the value proposition and products supplied, type of technology used, number of users, and geographical coverage. A total of 20 firms and projects headquartered in Kenya were selected as the most relevant for this study. Annex 1 describes how the firms were identified and selected.

Most firms are for-profit, and some non-profit or a social business, while one (G4AW) is a government project. In most cases, the main user interface is a mobile app, while for others the user interface could not be determined. One firm (Wefarm) uses SMS as the primary means of communication. Data on the number of users was often not available, possibly because they were very few, but some services have tens of hundreds of thousands of users.

Details of the value proposition and services supplied are found in the third column of Table 1. The next section discusses the types of services offered by the firms, while section 4.4 goes into depth with selected firms and services.

[2] The term "[int.3]" and so forth refers to the list of expert and firm interviews in Annex 1.

Table 1. Selected firms and projects providing agriculture ICT services in Kenya

FIRM OR PROJECT (YEAR)	TYPE OF SERVICE SUPPLIED	VALUE PROPOSITION AND SERVICE SUPPLIED	TYPE OF TECHNOLOGY	NO. OF USERS	NO. OF USERS
Safaricom (DigiFarm technology) (NA)	Supply chain management Financial management Market information and linkages Farm advisory and information	Agricultural and fin-tech mobile solutions (SMS and app services) for farmers. Increases access to knowledge, finance for inputs and access to markets within particular value chains.	SMS services and app.	1.3 million farmers	Kenya
eProd Solutions (2004)	Supply chain management Financial management Market information and linkages	Agricultural and fin-tech solutions (SMS and email services) to improve supply chain management for both farmers and suppliers	Supply chain management software	250,000 farmers across 12 countries	Guatemala, Kenya, Guinea, Ghana, Mali, Burkina, Nigeria, Rwanda, Tanzania, Malawi, Ethiopia
M-Advisory Africa (NA)	Farm advisory and information Financial management	Provides a call service advisory platform where farmers can get information on crop and livestock management as well as help with financial literacy. It is a multi-language service that delivers real-time answers to various queries.	Call service, tele conference	NA	Kenya
Agrics (2012)	Financial management Farm advisory and information	Builds sustainable businesses by providing smallholder farmers access to farm inputs, capital, innovation, knowledge and markets.	NA	35,000 farmers across Kenya and Tanzania.	Kenya, Tanzania
Dodore Kenya (Agri-wallet technology) (NA)	Financial management	Provides a fin-tech solution that ensures financial flow between the farmers, markets, agrovets/dealer and suppliers. Agri-wallet also offers loans and saving options for farmers.	Mobile wallet	NA	Kenya, Rwanda
Esoko (2008)	Supply chain management Financial management Market information and linkages Farm advisory and information	Connects farmers via mobile phone to information such as agronomic advice, weather forecasts, market linkages and insurance coverage over a range of channels including SMS, voice SMS and call centre.	Text and voice messages, bulk text messages (for organisations), videos, online market place, data collection tools.	50,000 farmers. Agri-businesses and projects buy subscription on behalf of the farmers.	Ghana and 8 other African countries
FarmDrive (NA)	Financial management	FarmDrive is an agricultural data analytics company that provides credit for farmers and helps financial institutions to increase loan portfolios in a sustainable way. Uses phone technology, alternative credit scoring, and machine learning	Mobile app	NA	Kenya
Geodata for Agriculture and Water project (G4AW) (NA)	Farm advisory and information	Government project. Makes tailor-made advice on fertilizer advice, market information, and general farm management support for individual farmers. The information is spread via a mobile platform and SMS system.	SMS service and mobile app	NA	Kenya, Tanzania

FIRM OR PROJECT (YEAR)	TYPE OF SERVICE SUPPLIED	VALUE PROPOSITION AND SERVICE SUPPLIED	TYPE OF TECHNOLOGY	NO. OF USERS	NO. OF USERS
Mezzanine (2012)	Supply chain management Financial management Market information and linkages Farm advisory and information	Delivers mobile, IoT and digital solutions for the areas of agriculture, health and social innovation, education, asset management and finance. Has co-developed DigiFarm with Safaricom.	Mobile apps used by both farmers and vendors.	See Safaricom	South Africa, Ghana, Nigeria, Mozambique, Zambia, Kenya and Tanzania.
MTela (NA)	Supply chain management Financial management Market information and linkages	Shop management app for agricultural input retailers, including sales and inventory management and simple input usage instructions for farmers. This is a mobile solution with 7 different features.	Mobile app	NA	Kenya
Twiga Foods (2014)	Financial management Market information and linkages	Business-to-business agricultural supply chain management and fin-tech solutions, which	Mobile app	+4000 suppliers, 35,000 + vendors	Kenya
Wazinsure (2016)	Financial management	Insurtech services for provision of micro insurances via data driven platform apps.	Mobile app	NA	Kenya
WeatherImpact (2014)	Farm advisory and information	WeatherImpact provides farmers with easy access to reliable weather and climate information with the goal to support and optimize food production while reducing the impact of climate change through mobile app services.	Mobile app	206,942 farmers across multiple countries.	Angola, Burundi, Ethiopia, Ghana, Kenya, Myanmar, South Africa, Netherlands
Wefarm platform (2015)	Market information and linkages Farm advisory and information	Farmer-to-farmer information exchange via SMS services for feature phones. The service should help farmers increase yields, gain pricing insights, tackle effects of climate change, source the best quality seeds, fertiliser etc.	SMS service and app service	2.4 million farmers have connected to each other. Farmers share +40,000 questions a day.	Kenya, Tanzania, Uganda, United Kingdom
DigiCow (Farmingtech Solutions) (2014; started operation in) 2016)	Farm advisory and information	Delivers veterinary advice on meat and dairy production. The app gives farmers peer-to-peer engagement through chatrooms, digital records and analysed reports, digital training rooms, expert consultancy through private chatrooms, and notifications on important gestation dates.	Mobile app, SMS services, IVR (interactive voice response) system	NA	Kenya
Yielder (NA)	Farm advisory and information	Information sharing app between farmers to help improve their agricultural production	Mobile app	NA	Kenyaz
FutureWater (ThirdEye Project) (NA)	Farm advisory and information	This project supports farmers with flying sensors to enable them to improve decision making on limited resources such as seeds, water, fertilizers and labour.	Drones and mobile phone	NA	Several African and European countries

FIRM OR PROJECT (YEAR)	TYPE OF SERVICE SUPPLIED	VALUE PROPOSITION AND SERVICE SUPPLIED	TYPE OF TECHNOLOGY	NO. OF USERS	NO. OF USERS
Tahmo (NA)	Farm advisory and information	Large project that builds weather stations Africa. Weather data is freely available and can enhance crop modelling and crop insurance.	Weather stations	The aim is to develop a dense network of 20,000 weather stations across Africa.	Multiple countries
ifarm360 (2020)	Market information and linkages Financial management	Wholesale market service connecting fresh-produce farmers to buyers through storage and distribution hub enabled by WhatsApp or web store. Crowd-funding platform for farm investment. Farmer wallet-payment and savings.	Mobile app and ICT ecosystem. Web store. Logistics.	+300 farmers	Kenya
VanderSat (NA)	Farm advisory and information	Uses satellite technology to deliver daily data on soil moisture, temperature and vegetation to power different applications	Satellite technology (passive microwave sensing).	NA	Based in The Netherlands and South Africa.

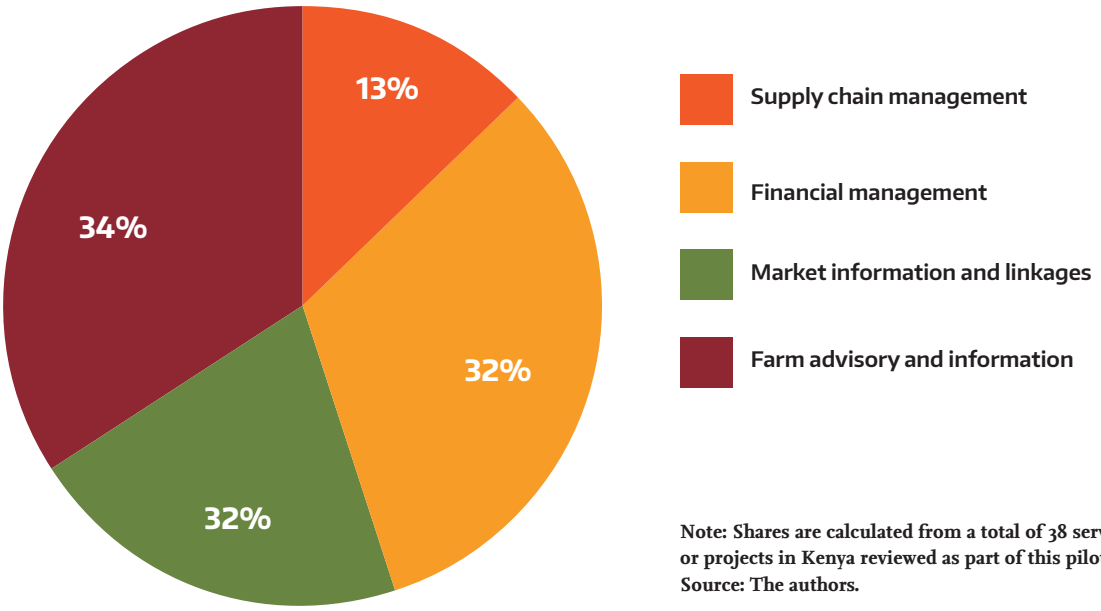
Source: The authors, based on expert and firm interviews and a review of websites and documents.

4.2 Types of agriculture ICT services supplied by Kenyan firms

The study identified four main types of services and usages dominating the ICT market within agriculture in Kenya: farm advisory and information services (agronomic and weather information), services providing market information (typically market prices) or market linkages (typically between farmers and traders), more advanced supply-chain management tools, and financial management services facilitating payments and/or access to finance for farmers and traders.

A total of 38 such services were offered by the 20 firms or projects listed in Table 1. Figure 1 shows how these services are distributed among the four types, with farm advisory services being the most common, closely followed by financial management. It is interesting to observe from Table 1 that many firms offer multiple services: five firms offer three or four services, five firms offer two services, while ten firms offer only one service. Among the 10 firms offering multiple services, nine offer financial management as part of the package, making this the most preferred supplementary service, followed by market information and linkages (eight instances). Below we discuss key aspects and trends in these services, drawing on expert opinions or literature.

Figure 1. Distribution of types of ICT services supplied by 20 Kenyan firms or projects



Note: Shares are calculated from a total of 38 services offered by 20 firms or projects in Kenya reviewed as part of this pilot study.
Source: The authors.

Farm advisory and information

Access to farm advisory (extension) services is limited for many farmers and ICT services provide platforms where farmers can receive advice on climate and weather, farming practices for cash crops, etc. Hence, advisory services have been among the major drivers within ICT for agriculture [int. 4]. ICT-based advisory services such as the Wefarm platform do not necessarily require high-tech solutions, smartphone ownership or internet connection for farmers to receive advice [int. 1], although these factors will limit the use of potentially more effective communication channels such as images, video and social media.

Market information and linkages: assuring product quality and traceability

The ability to trace a particular product from a specific farm all the way to the consumer has become increasingly important in agricultural value chains, especially for high-value crops [int. 2, 4]. One expert highlighted that the growing middle-income class in Kenya demands increased traceability of the origin of food products [int. 4]. This consumer segment is becoming increasingly interested in how the food has been produced, e.g., in terms of the use of good agricultural practices, particularly safe use of chemical inputs. They also increasingly

demand products that comply with environmental and/or ethical standards, e.g. organic and fair trade standards. There is also a desire to better understand the role of middle-men who are often accused of cheating farmers and inflating prices [int. 4].

Some experts also highlight the fact that many ICT services have moved from farm advice onto market intelligence and interventions, including services that provide market prices and that connect producers and buyers [int. 5]. The largest impact of digitalisation to date may therefore be improved market access for farmers and more transparent markets generally, rather than higher farm productivity. When farmers get access to market prices, they obtain more bargaining power vis-á-vis the buyers. Better market information also reduces the risk of product losses during storage [int. 5], as long as other factors such as access to transport and storage facilities do not limit the ability to make use of improved market intelligence. That said, systematic evidence is lacking to verify such impacts.

Supply chain management: data collection and analytics

The increasing number of ICT platforms has increased the availability of data on agricultural value chains in Kenya, which may be availed to, and used by, value-chain actors, from farmers to consumers. In particular, large agri-businesses have created a strong demand for reliable, comparable and timely data collection, which can more effectively link farmers with traders or contract-farming scheme operators, improve traceability, and assure product quality. Moreover, the growing amount of information generated by and through ICT services enables data aggregation and analytics, which may be used to develop more specialised and effective supply chains. Especially large companies demand, or have developed their own, ICT systems and platforms for data collection and analysis, using them in supply-chain management and optimization [int. 5].

Financial management: facilitating market transactions and improving access to finance

Financial services based on ICT (fin-tech) has become an important part of the portfolio of ICT solutions for agricultural value chains in Kenya and elsewhere in Africa [2,8,15]. More than half of the firms listed in Table 1 provide such services; in three cases (Dodore/Agri-wallet, FarmDrive, Wazinsure) it is the only service offered, and in nine cases in conjunction with a broader portfolio of services. Regarding the latter, mobile money (transactions) is becoming a necessary part of services linking farmers to buyers (wholesalers or consumers), such as those provided by Twiga Foods and ifarm360, and has become an integral part of more advanced supply-chain or contract-farming management platforms, such as the one by eProd.

Several services facilitate farmers' access to finance; indirectly through credit assessment based on data analytics (FarmDrive) or as direct credit delivery (DigiFarm, Twiga, Dodore/Agri-wallet). One firm (ifarm360) provides a crowdfunding platform, whereby farmers are provided with equity for specific investment projects. Often these credit facilities are combined with savings options as farmers often need to accrue some savings to obtain credit. Data analytics is also used by Wazinsure as a basis for facilitating insurance to small farms and businesses by increasing transparency and reducing costs in risk assessment and the processing of claims.

4.3 Barriers to the diffusion and uptake of ICTs and related services within agriculture

It is clear that ICTs and the services they enable have the potential to play a key role in improving smallholder farmers' economic opportunities, whether by increased access to extension services or through more value-chain transparency and better management. However, while the above-mentioned ICT services have a high value proposition on paper, all the experts questioned the current level of uptake and impact on the livelihoods of smallholder farmers. Indeed, ICT extension services only reach a relatively low number of farmers. This section discusses some of the challenges, barriers and underlying reasons in relation to the current structure and status of the ICT market that can help explain the slow dissemination and uptake of these ICTs and ICT-based services.

Failure to reach or be relevant to end users

ICT services can improve the distribution of extension services to reach more farmers, and this is especially important in a country like Kenya, where only 21% of farmers are reporting to have had contact with a public-sector extension agent [16]. Yet various challenges exist to limit the effective reach of ICT services for extension. Language is among the main barriers of uptake of these ICT services. Kenya is a multilingual country with around 68 different local languages, while

most apps exclusively provide content in English, which means that the ICT extension services in practice do not reach a significant number of smallholders [interviews #1, 5]. Moreover, the average age of farmers in Kenya is 60 and illiteracy is common in rural areas, and few if any services provide information in verbal form.

Another major barrier to ICT service uptake and diffusion is the fact that smartphone penetration is mostly occurring among the younger population [int. 3] while many of the available ICT services and apps use subscriptions and data-heavy images for instance to communicate on market produce [int. 1]. This tends to exclude a large segment of elderly smallholder farmers who only own a feature mobile phone. Moreover, many rural areas have either very poor or no mobile network coverage and some remote areas are without electricity, which further inhibits farmers from getting access to the ICT services [int. #1, 3].

Finally, farm size and market orientation can limit farmers' incentives to adopt ICT services. One expert emphasized the very small size of many farms in Kenya and observed that smallholder farmers are only selling to the local market, which makes many ICT applications unsuitable to them, even if the developers are trying to target smallholders [int. #3].

Technology development is not demand-driven or responding to user experience

A main reason why many apps and ICT projects are unsustainable and fail to deliver 'real change' for farmers is that the products and services are developed based on a technology-push approach rather than an analysis of latent demand. Often technologies were developed by ICT firms that did not involve users in the innovation process, nor understood the social and economic context in which their technology would be applied, resulting in a failure to meet the needs of the farmers.[3] Instead, it was observed that "the content has to be demand driven, relevant, and in the right language." [int. 5].

Constraints facing farmers to act on information provided

Agricultural markets often involve complex relationships between farmers and traders. For example, a farmer may get credit from the same trader to whom she sells her products, which means the farmer cannot sell to the highest bidder as she is tied to this particular trader through so-called interlinked contracts [int. 5]. It may also be that the farmer does not have the means of transport to reach a more distant market offering higher prices and so is compelled to accept the lower prices offered by local traders. Thus, while the farmer may have access to information on market prices through an ICT service, she may not be able to act upon the information, making the service ineffective. In other words, information is only useful if you are able to act on it [int. 5].

Competition from free services and low profitability of ICT solutions

A key challenge for ICT developers is the ability to make a realistic evaluation of their product or innovation in light of other products already in the market. The existence of competing products, which are free to use, such as social media applications, makes it challenging for these firms to establish profitable business models. Logically farmers will have a low willingness to pay for bespoke ICT services if they perceive that there are free alternatives that already serve their needs, especially if they are unsure of the usefulness of the services.

Hence farmers increasingly use free social media platforms, notably WhatsApp groups, Facebook groups, Google groups, and Twitter [interviews #1, 3], where they can advertise and sell their products or get quick agronomic advice in their local language and from peers living in a similar context:

"I don't use a specific application. I can use social media itself, e.g. Google Groups, Facebook groups for chicken farmers. So the need for specialised agric apps has been diluted by social media apps such as Twitter, where you can advertise. For example, I bought turkeys in this way. For extension, we have peer advice in Facebook groups or WhatsApp groups, where you can get answers too […]" [int. 3]

[3] This finding is corroborated by the research literature demonstrating that failing to involve technology end-users in the design process increases the risk of taking into account of the socio-economic, biophysical or technical context in which the technology will be used, in turn reducing its usability and sustainability.

More and more farmers use smartphones to go online to look for information beyond the traditional extension services. This has been particularly evident during the Covid-19 lockdown where the number of local WhatsApp platforms for information sharing among farmers grew significantly [int. 1]. These groups are free, quick and work in a local context, which makes information for farmers free and readily available.

In general, ICTs offered by private companies are difficult to sell to farmers as they often struggle to see how the benefits of a specific service outweigh the financial costs. In other words, farmers find such ICT solutions too costly and/or having unsubstantial effects on their farming business, which makes them unsustainable in the long term and thus they die out before they get properly anchored and can spread in the market [int. 5].

One expert explained that for a company to develop a database with site-specific information on different crops, soils, climates, fertiliser needs, and in different local languages, requires "serious investments at the backend" [int. 5]. Few companies have the required technical or financial capacity to make such investments, and the profitability is uncertain due to low uptake and willingness to pay among farmers. Especially given the availability of free, though more generic social media platforms, as explained above.

4.4 Solutions and revenue models that address ICT diffusion challenges

Creating sustainable revenue models with realistic pricing levels, which enable farmers to adopt the service while also earning profit for the company is crucial. But it is also one of the biggest challenges among the Kenyan ICT companies. Below are four examples of firms applying different revenue models that address some of the challenges of technology diffusion and uptake discussed above.

DigiFarm by Safaricom

DigiFarm is an integrated mobile platform for smallholder farmers. The platform offers access to knowledge, finance to buy input, and increases access to markets. To do so, DigiFarm has built a consortium with other ICT-based firms (i.e. iProcure, FarmDrive, Arifu, iCow and iShamba) based on a shared revenue model. DigiFarm has already reached 1.3 million farmers across several counties in Kenya. What is special about DigiFarm is that it is owned by the Kenyan mobile network operator, Safaricom, which is listed among the biggest companies in East Africa. The Kenyan government owns 35% of Safaricom, South Africa's Vodacom owns 40%, while the remaining shares are listed. Moreover, Safaricom owns the mobile money service M-PESA, which is a service that enables users to transfer funds, save money in their savings accounts, and buy airtime and bundles.

This ownership model and market power gives Safaricom a strong economy of scope as the service makes it easy for Safaricom to integrate financial and market services to their products, which is highly desired. Moreover, DigiFarm is a free platform for customers that are already a Safaricom subscriber. Thus, the distribution of DigiFarm happens almost automatically and perhaps these free benefits may attract farmers to subscribe to Safaricom. The backing from Safaricom makes both distribution and development of the service much easier and less problematic as Safaricom can afford to operate a face-value loss on DigiFarm [int. 6].

M-Advisory Africa

M-Advisory Africa offers farmers real-time information and advice on various queries to support farmer's decision making along the value chain. The company delivers extension services on the phone, where farmers can call the local extension officer who will provide advice and content in the right language. The parent company M-Advisory has developed its own billing service in Bangladesh. According to the CEO, M-Advisory offers a mobile virtual network operator (MVNO) billing model, charging subscribers as little as 1 USD/month payment [int. 7]. However, this business model, and indeed any service-specific subscription fees, face challenges in Kenya due to the market power of the DigiFarm app and multiple free social media apps.

eProd Solutions

Based in Kenya, eProd is a Dutch-owned ICT company founded in 2004. eProd provides a supply-chain management tool for both small and large agribusinesses such as contract farming scheme operators, exporters, food processors, aggregators of different agricultural products, and cooperatives/unions to manage their different supply chains. The company serves around 75 such clients, which together contracts, certifies or trades with around 250,000 farmers, covering 22 different agricultural sectors in 10 languages across 12 countries. Their services are varying from HR monitoring, contact modules, where groups can get connected, fully traceable product systems, which includes certification schemes,

communication modules, flexible and quality-based payment systems, product and stock modules as well as flexible loan modules. The system is thoroughly developed and successfully used by several agribusinesses in Kenya, according to eProd [int. 8].

eProd operated as a paper-based system for 11 years before it developed its digital system and commercialized it. The paper version is still available for clients who have not been able to adopt the online system, making the system very flexible. Understanding the context and challenges of clients is crucial for successful configuration and implementation of the system and eProd spends a lot of time in the initial stage to ensure the best implementation [int. 8]. This includes on-site trainings, system and payment configuration to suit the clients, and weekly client contact for support and uses satisfactory surveys throughout the process. This also builds trusted relationships. Moreover, eProd is very robust in internet-weak areas, which makes the product competitive compared to other services that often require 3G or 4G to operate. Lastly, the business and pricing model needs to be affordable and reflect the relatively small output of each farmer in African countries, and the fee charged to agribusinesses is currently around 0.5 USD per farmer per year [int. 8].

ESOKO

ESOKO was set up by British technology entrepreneur Mark Davies in 2008, offering customised services to various projects, initially in Ghana. Their aim is to offer a platform that integrates the whole supply chain, not to just provide prices for farmers. The company serves about 50,000 farmers in Ghana and eight other African countries, each paying a monthly subscription of 1USD, though agribusinesses and projects tend to pay for subscriptions on behalf of the farmers. ESOKO's partners and customers include Technoserve, ActionAid, CCAFS, USAID, MTN, GIZ, Prestat, NYU, IFDC, FAO, IFAD, Novus International, AECOM and IFPRI.

At the outset ESOKO was focused on the provision of content services to farmers such as agronomic advice or price information, but in recent years the company has introduced additional services like digital credit, insurance, payments and transaction services. ESOKO moreover now also provides data collection and digitization tools, biometric profiling, analytics, as well as communication services to its agribusiness and project customers. Hence, the company serves its customers through two pathways: service delivery and data collection and profiling.

Why some firms and solutions succeed

Agricultural value-chain actors in Kenya make use of ICT services but they often use other channels than those provided by the Kenyan ICT companies, typically free social media platforms, as mentioned. According to one expert, the ICT companies that do succeed are those that understand the local context and dynamics and are able to develop different services tailored to the needs of the farmers in different situations [int. 5]. Moreover, the study identified the following important factors of success for ICT services in the Kenyan agricultural sector:

- The use of marketing strategies and social media. This could include using local champions as part of marketing strategies to promote the service.
- The ICT service must be very simple and easy to use, but also flexible and accommodating to the local context. Payment services must also be accustomed the farmers' needs and conditions.
- The ICT service must work in areas with no or poor internet (e.g. 1G, 2G networks) and power infrastructure and should work on both smartphones and feature phones to accommodate the widespread 'digital poverty' among Kenyan farmers.
- The value proposition to farmers, of especially payment services, needs to be clearly articulated and based on a real need or demand from farmers.
- Services need to be very low-cost and affordable for farmers. The cost of services should ideally not be placed with the farmers, but (shared) with other stakeholders (e.g. horticultural exporters, traders, consumers)
- Focusing on a particular value chain often reduces the complexity of the system, making it easier to use.

5. Challenges and opportunities of digitalisation in African agriculture

Climate change, in addition to a range of other natural as well as market factors, clearly presents risks to agricultural productivity and farmer livelihoods in Kenya, yet the current role and importance of ICTs in offering solutions to these problems do not appear to match the great expectations or hype surrounding the transformative effect of ICT technologies. Several challenges remain in this emerging market:

- The ICT sector is characterised by numerous SMEs and start-ups, while only a few firms have managed to grow to a larger size. Both the firms and their technologies depend strongly on continued donor and project support and few are commercially sustainable or viable.

- Many services or solutions lack convincing revenue models, as the willingness to pay is generally low among end users (farmers, consumers); only businesses and projects are willing to pay subscription fees. In a few cases, advertising may generate some revenue, but radio and TV are the preferred channels. There are several free platforms for e-commerce and information exchange that offer easy and popular information exchange, e.g. Facebook and WhatsApp groups.

- The level of adoption among farmers and other end-users outside schemes and projects is low, except in the case of mobility and mobile money. Many solutions are not well adapted to the real-world constraints facing end users.

- The physical IT and other infrastructures necessary for creating value of the ICT solutions are underdeveloped or very costly. For example, crop storage facilities and cold chains, mobile networks, affordable smartphones, Wi-Fi, computers, cloud facilities, etc.

5.1 Implications for policy and practice

Based on the evidence gathered and analysed in this issue brief, there are numerous implications for policy and practice in neighbouring countries keen to understand what they can learn from the Kenyan experience. Firstly, it is clear that free-to-use social media platforms for smartphone technologies offer a powerful solution to the basic information sharing needs of smallholder farmers. As mobile networks expand into rural areas across Africa and the urban-rural 'digital divide' is closed, such platforms are likely to serve as the to-go solution for otherwise low-income farmers as the dominant social media applications, e.g. Facebook and WhatsApp benefit from a strong incumbency effect.

Secondly, where more sector-specific digital solutions have been developed in Kenya, it is useful to highlight two key factors. The first is that where subscription-based services have been used by small-scale farmers, these have been paid for by the larger commercial buyers and market intermediaries looking to gather harmonised data from their suppliers, as part of supply-chain management and business optimisation. The second point is that these digital solutions were invariably commercialised with the help of donor funding, at least in the early phases of technology development, testing and roll out. Market forces alone are not sufficient to kick-start the supply of digital solutions in the African agricultural sector, even if there is a discernible need and latent demand. As with many new innovations and processes of technology diffusion, this market has to be created and nurtured with the support of public funds, ideally in support of nationally-driven digitalisation and/or development strategies and NDCs.

References

[1] K. Schroeder, J. Lampietti, G. Elabed, What's Cooking: Digital Transformation of the Agrifood System. Agriculture and Food Series, The World Bank, Washington, DC, 2021. https://doi.org/10.1596/978-1-4648-1657-4.

[2] Dalberg Advisors, CTA, The Digitalisation of African Agriculture Report 2018 - 2019, Proud Press, The Netherlands, 2019. https://www.cta.int/en/digitalisation-agriculture-africa.

[3] Food and Agriculture Organization of the United Nations, Kenya at a glance, FAO Kenya. (2021). http://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/ (April 30, 2020).

[4] The World Bank Group, Climate Risk Country Profile - Kenya, (2021). www.worldbank.org.

[5] S.T. Hornum, S. Bolwig, The Growth of Small-Scale Irrigation in Kenya. The Role of Private Firms in Technology Diffusion, UNEP DTU Partnership, Copenhagen, 2020. https://unepdtu.org/publications/the-growth-of-small-scale-irrigation-in-kenya/

[6] F.J. Meza, J.W. Hansen, D. Osgood, Economic value of seasonal climate forecasts for agriculture: Review of ex-ante assessments and recommendations for future research, J. Appl. Meteorol. Climatol. 47 (2008) 1269–1286. https://doi.org/10.1175/2007JAMC1540.1.

[7] R.S. Newfarmer, J. Page, F. Tarp, Industries without Smokestacks. Industrialization in Africa Reconsidered, Oxford University Press, Oxford, 2018. https://www.wider.unu.edu/publication/industries-without-smokestacks-2.

[8] GSMA Intelligence, The Mobile Economy. Africa 2016, 2016. www.gsmaintelligence.com.

[9] Pew Research Center, Internet Connectivity Seen as Having Positive Impact on Life in Sub-Saharan Africa, 2018. www.pewresearch.org.

[10] B. Bishaw, H. Neufeldt, J. Mowo, Farmers ' Strategies for Adapting to and Mitigating Climate Variability and Change through Agroforestry in Ethiopia and Kenya, Corvallis, 2013. https://ir.library.oregonstate.edu/concern/defaults/5999n3901

[11] J.S. Tata, P.E. McNamara, Impact of ICT on agricultural extension services delivery: evidence from the Catholic Relief Services SMART skills and Farmbook projectin Kenya*, J. Agric. Educ. Ext. 24 (2018) 89–110. https://doi.org/10.1080/1389224X.2017.1387160.

[12] F. Cavazza, F. Galioto, M. Raggi, D. Viaggi, The Role of ICT in Improving Sequential Decisions for Water Management in Agriculture, Water. 10 (2018) 1141. https://doi.org/10.3390/w10091141.

[13] P. Roudier, B. Muller, P. D'Aquino, C. Roncoli, M.A. Soumaré, L. Batté, B. Sultan, The role of climate forecasts in smallholder agriculture: Lessons from participatory research in two communities in Senegal, Clim. Risk Manag. 2 (2014) 42–55. https://doi.org/10.1016/j.crm.2014.02.001

[14] Y. Kusunose, R. Mahmood, Imperfect forecasts and decision making in agriculture, Agric. Syst. 146 (2016) 103–110. https://doi.org/10.1016/j.agsy.2016.04.006

[15] GSMA, Improving financial inclusion through data for smallholder farmers in Kenya, 2019. https://www.gsma.com/mobilefordevelopment/resources/improving-financial-inclusion-through-data-for-smallholder-farmers-in-kenya/ (April 28, 2020).

[16] Local Development Research Institute, Extension Support Program, (2021). https://www.developlocal.org/esp/ (December 13, 2021).

[17] L. Rosencrance, USSD (Unstructured Supplementary Service Data), TechTarget. (2021).

Annex 1. Methodology of the pilot study

Both primary (interviews) and secondary (desktop review of literature) sources of data were used to examine the research objectives. Primary data collection consisted of semi-structured interviews with local ICT firms as well as experts within the field of ICT in developing countries. Two interview guides were prepared with experts and firms, inspired by the business model canvas to understand how ICT firms develop their business models to generate value for agriculture and how it evolves according to the surrounding market, barriers and opportunities. The structure and content of the interview guides were adapted to address the research objectives and tailored to fit firms and experts respectively, reviewed internally and revised to ensure data quality and effectiveness. Table A.1 shows the overall structure and topics covered by the interview guides, the detailed interview guides may be obtained from the authors upon request.

Table A1: Overall structure and content of semi-structured interview guides

MAIN ELEMENT		MAIN VARIABLE / TOPIC
Firm interviews	Background information	Education, work background and ICT experience Value offering to customer and society, customers and customer relationships Price and revenue, activities and processes, stakeholders and partners, resources and costs, profit Technology, skills and capabilities, technology and roles of partners and linkages, opportunities (market formation)
	Value proposition & customers	
	Value creation and capture	
	Technology capabilities and innovation	
Expert interviews	Background information	Education, work background and ICT experience ICT market demands and trends, ICT firm characterization Users, barriers and incentives for adoption of technology Main value-chain actors and funding activities Technology innovation, skills, infrastructure and regulation
	Market development and value creation	
	ICT adoption	
	Stakeholders, partners and funding Technology innovation, skills, infrastructure and regulation	

In total eight interviews were completed using these guides; three interviews with ICT firms in Kenya, and five with ICT for agriculture subject specialists, with one exception, based in Kenya or Uganda (see below). Each interview lasted around 1-1.5 hours and were carried out online via Zoom in November and December 2020. All interviews were recorded and comprehensive notes were taken during each interview.

Table A2: List of interviews in pilot study

INTERVIEW NO.	TYPE OF ORGANISATION	POSITION OR ROLE
1	Research	CTO/IT Director
2	Ministry	Communication & Knowledge Management Specialist
3	Development programme	Digital Innovations Specialist
4	Research and outreach	Director for Research
5	International development organisation	Chief Economist
6	Large ICT company	General Manager
7	Small ICT company	Founder
8	Small ICT company	Founder and Director

Note: The interviewees were anonymised for purpose of publication.

Firms were identified through a comprehensive online and literature search for ICT firms based primarily in Kenya and East Africa, conducted between July – December 2020. The identification method included google search terms such as "agriculture mobile app Kenya", and "ICT for agriculture East Africa Kenya". The 'Findit' search engine of the Technical University of Denmark (DTU) was also used, specifying the outcome by creating a search string that allowed the most relevant studies to be released. The string "ICT agriculture innovation system"; Year: 2017 – 2020; journal articles only" was used. These two methods lead us to both relevant firms and experts directly, but it also enabled a snowball sampling as many of the search results referred to other firms and experts as well as other relevant reports and articles.

Based on the above search, a list of 31 ICT organisations was compiled that offer ICT services for agriculture, of which 20 are based in Kenya. The organisations were then categorised according to type (private firm, government, NGO) and the types of services provided by them were identified: farm advisory and information, market information and linkages, supply chain management, or financial management. Among the 31 firms, 12 Kenyan firms were selected for the first round of interviews, based on a preliminary assessment of how advanced they are in terms of ICT technology, size and coverage. In this pilot project, we then carried out interviews with three firms (Table A.2).

For the selection of subject specialists for interview, relevant authors and experts within the field of ICT in agriculture in developing countries were identified. Some already in advance and others following an online search and/or snowballing effect (Table A.2). All interviewees were contacted via email and/or LinkedIn.

Data analysis

In the preliminary analysis, interview data were extracted based on two sets of notes taken during the interviews, but the interviews were not transcribed. All the interviews are available as audio and video files. Citations from the interviews were used to illustrate general points.

Data limitations

During the firm and expert selection process, several limitations were encountered, including a low response rate, which meant going down the list of priority interviewees. Consequently, the current list of interviewed firms is shaped by response and not just representativeness. Moreover, the search and selection of firms were based on firms mentioned in the literature or websites, meaning that potentially relevant local firms with less visibility may have been left out of the research. Regarding the interview data, some interviewees did not have time to answer all the questions, such that some sections had to be skipped from the interview. Lastly, data was not collected on customer experience, from e.g. farmers, traders etc., which limits the analysis of barriers and opportunities for ICT technology adoption. While such information to some extent can be found in the literature, systematic impact studies of ICT in agriculture are relatively rare.

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