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Digital Tools and Agricultural Market Transformation in Africa

Why Are They Not at Scale Yet, and What Will It Take to Get There?

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Abstract

Despite enthusiasm on the potential of digital innovations to transform agricultural markets in Africa, progress made thus far has been limited to small-scale experiments that often fail to scale up. Realizing the full potential of digital innovations—tools, technologies, applications, and services—in Africa requires not just further development of these solutions at meaningful scales, but also more nuanced evidence from both successful and unsuccessful scaling efforts. This paper reviews the theoretical and empirical evidence on the transformative potential of digital innovations for African agricultural markets with an in-depth examination of solutions that have been rolled out to date in the continent. Specifically, the review addresses the following questions: (i) how can digital innovations improve the functioning of agricultural markets in Africa? (ii) what explains the apparent failure of most pilots to scale up? (iii) what is required to realize their full potential? and (iv) what are the emerging risks and opportunities associated with these digital innovations for agricultural marketing? Although our review of the landscape and literature on market-focused digital innovations in Africa identifies several reasons to remain optimistic, the prevailing disconnect between pilots and scale-ups merits further evaluation. In particular, there is a need for more systematic assessments of both successes and failures at different stages of piloting and scaling of digital solutions.

Keywords: Digital innovations, agricultural markets, market information, digital divide.

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1. Introduction

The potential of digital tools to transform agricultural markets in developing countries has attracted substantial enthusiasm in public discourse, development policy, and private enterprise and investment circles. The near ubiquity of mobile phones and growing internet connectivity in the developing world represents an undeniably fertile landscape for the potential deployment of information and communication technologies (ICTs). ICTs, ranging from text message and interactive voice response (IVR) to mobile apps, satellite imaging and remote sensing, have the capacity to be customized to varying contexts to deliver services and information in a low-cost, large-scale, and timely manner. Among their many contributions, ICTs can considerably transform agricultural markets, including their structure, organization, and functions, with significant potential to address some of the persistent market failures and information asymmetries that are often found in developing countries (e.g., Jensen, 2007; Aker, 2010; Goyal, 2010; Courtois and Subervie, 2014; Nakasone et al., 2014; Aker and Fafchamps, 2014; Aker et al., 2016; World Bank, 2016).

This potential has motivated a large number of public and private sector initiatives to build digital tools, platforms, and architectures that aim to radically transform agricultural markets. Much of this effort has focused on Africa, where markets are comparatively underdeveloped, and agricultural production is carried out primarily by smallholder farmers operating small, fragmented farms which are often distant from urban areas (Aker et al., 2016). These initiatives have led to a proliferation of digital innovations that aim to address a very specific and critical piece of the puzzle: marketing constraints. Most of these innovations provide platforms to match buyers and sellers, increase access to price information, and reduce the costs and risks of exchanges in goods and services. More formally, these innovations aim to address multiple forms and sources of both market and institutional failures that are common in agricultural markets (Dorward et al., 2004). These innovations respond to a fairly well articulated need that has been detailed throughout the early literature on ICTs in agriculture and their potential role in remedying information asymmetries between farmers and traders relating to product quality, price, and transactions costs through contract mechanisms, both implicit and explicit (Jensen 2007; Aker, 2010; Goyal, 2010; Courtois and Subervie, 2014; Aker, 2016).

But in spite of the potential of these digital innovations, systematic evidence of their impact remains scant and the few existing pieces of evidence are mostly based on pilot projects with

unknown (or at least undocumented) scaling experience. On the basis of available evidence, there are very few digital innovations that can demonstrate success in terms of developing or integrating markets, reducing transaction and transportation costs, improving coordination or consolidation of long and fragmented value chains, reducing production and market risk of both idiosyncratic and covariate natures, or in terms of remedying the unequal distribution of market power among agents (e.g., Goyal, 2010; Courtois and Subervie, 2014; Aker, 2016; Benami and Carter, 2021).[1] Despite ambitious claims of speed, reach, and depth, purveyors of ICT tools have thus far posted only a few large-scale successes that have substantially transformed agricultural markets in Africa.

However, it may be too early to expect impacts at scale. While the growth of mobile connectivity has been explosive, Africa still lags behind other regions on ICT and mobile internet connectivity rates vary highly within the region (ITU, 2020; GSMA, 2021a).[2] But it may also be that too little attention is being given to the complex nature of agricultural markets in Africa – markets that involve multiple layers of formal and informal exchanges, intransigent structures and agents, and gaps in digital connectivity that together create unique and sometimes unsurmountable challenges to transformative structural change in market development.

For example, addressing smallholders' market constraints adequately may require end-to-end digital solutions rather than piecemeal informational apps in an environment characterized by isolation and risky transactions. Unlike the delivery of extension information or agronomic advisory services, the provision of marketing support typically requires whole-of-value-chain coordination: identifying multiple suppliers and consumers of products and services along a value chain, coordinating post-harvest, transport, processing, and warehousing activities, and facilitating services such as price information and payment and credit transactions. Few ICT-based tools targeting agricultural markets are able to fully address multiple constraints on a single platform. For example, those tools that only deliver a specific service (e.g., information) without facilitating transaction (e.g., payment systems) may simply fall short of the mark.

[1] Some exceptions include digital tools that facilitate financial transactions (e.g., M-Pesa and M-Shwari in Kenya), which has achieved significant scale. However, these tools are still not widely available to smallholder farmers and agricultural households. A recent paper by Parlasca et al. (2022) show that the use of Mobile Financial Services (MFS) for facilitating agricultural financial services remains limited; about 1% of Kenyan farmers use MFS for getting agricultural loan and only 15% farmers use them for agricultural related payments. Thus, Parlasca et al. (2022) conclude that these tools "do not yet have a transformative impact on smallholder farming."

[2] In this review, the term "Africa" refers to the economies that are geographically situated within all the African continent, not only those that are referred to as economies or countries located "south of the Sahara".

Furthermore, although the proliferation of new technology companies in many African countries remains encouraging, adoption of their products and services remains limited. Thus far, efforts to promote the adoption of digital marketing tools have required generous subsidies and incentives from governments and donors, with few such tools standing on their own as commercially viable products. Indeed, most digital tools and innovations targeting smallholder farmers in African countries remain at pilot stages, with unknown potential for successful scaling (World Bank, 2016; Baumüller, 2018; Fabregas et al., 2019a; 2019b).[3]

Realizing the promise of digital technologies to transform African agricultural markets is likely to require much more investment and learning from large-scale and successful scaling-up efforts. In particular, there is a paucity of empirical evidence on what works where and under which conditions, in terms of design, content, scaling strategies, and the presence of financial and other institutional enabling factors. More systematic and comprehensive evaluations of current activities and progress may help to shape more effective modalities and partnerships to ensure sustainable delivery of digital marketing services in agriculture. These same evaluations may also contribute to addressing institutional constraints that inhibit the mainstreaming and integration of digital tools into national agricultural marketing systems and practices.

The objective of this paper is to identify encouraging developments and success stories that inform us about the potential of digital innovations to transform agricultural markets in Africa. To do so, the paper reviews the theoretical and empirical evidence on the potential of digital tools to transform agricultural markets in Africa. In particular, this review aims to address the following questions: (i) how can digital tools improve the functioning of agricultural markets in Africa? (ii) what explains the apparent failure of most pilots to scale up? (iii) what does it take to realize the potentials of digital solutions in African agricultural markets? (iv) what are the emerging risks and opportunities associated with the advent of new digital tools for agricultural marketing?

We first document how digital tools may transform agricultural markets in Africa. We then compile an inventory of market-oriented digital tools along with a characterization of their attributes, followed by a systematic review of the new ideas and partnerships that may address the disconnect between pilots and scaling up of digital innovations and tools meant to transform the

[3] This failure to scale up is not unique to Africa and agricultural markets. For example, The World Bank (2016) argues that, globally, four out of five startup online commerce platforms are likely to fail to scale up successfully.

functioning of rural markets in Africa. The review also discuss how African countries can harness digital solutions and reflect on encouraging trends and emerging risks.

It is worth noting that this is not the first review on ICTs in agriculture: several other papers evaluate the potential of digital tools to transform agriculture, albeit with different foci and coverage. Aker and Mbiti (2010) and Aker et al. (2016) provide a comprehensive review of the earlier literature on the potential of ICTs to provide various types of agricultural extension and related services. Fabregas et al. (2019a) and Spielman et al. (2021) review recent literature on the effectiveness of ICTs to deliver agricultural extension and advisory services in developing countries, while another recent review by Benami and Carter (2021) synthesizes the potential of digital technologies to reshape rural microfinance. Nakasone et al. (2014) and Nakasone and Torero (2016) discuss the potential of ICTs to support agricultural development, including through market information systems (for which they do not find strong evidence of impacts on prices). While they note the paucity of empirical evidence on marketing outcomes, they do acknowledge possible heterogeneities of impacts across different types of actors and value chains. CTA (2019) provides what we believe to be the most extensive inventory of agriculture-focused digital technologies in Africa, identifying 390 unique technologies in Africa. However, most of these innovations are still at early stages of development and operate at small scale.

Our paper differs from these reviews in several ways. First, we provide a higher-resolution analysis of digital innovations that specifically address market-related issues. We analyze these innovations within a typology of market-related services, covering four distinct categories: (a) market advisory and information services that provide price information; (b) agricultural e-marketing tools that facilitate market linkages; (c) e-financial services that facilitate a range of financial transactions; and (d) tools that collect agricultural market data such as demand and supply and provide crowdsourcing services. This typology provides the focus needed to characterize and distinguish different types of digital innovations that are otherwise perceived as relatively similar.

Second, we draw on a substantive list of digital tools in agriculture to populate our typology and examine each type-class more systematically. Third, our review covers more recent innovations and evaluations than prior reviews, keeping pace with the rapidly evolving ICT sector that renders many prior reviews obsolete in a short amount of time.[4] Finally, our review limits

[4] A report by the Center for Technical Agriculture (CTA, 2019) documents that, as of 2019, there are at least 390 distinct, active digital solutions focusing on agriculture, with two-thirds of these digital innovations having been launched during the three years preceding their survey.

itself to digital innovations in African agricultural markets. Although these markets share many commonalities with markets in other developing regions, there are arguably unique attributes of many agricultural markets in Africa—most notably, the considerable market fragmentation, limited spatial integration, and infrastructural constraints, all of which digital innovations seeks to address—that warrant this focused attention.

2. How can digital tools transform agricultural markets in Africa?

A relatively large literature has examined the potential of digital tools to transform the functioning of agricultural markets and the efficiency of agents by addressing critical market failures (e.g., Jensen, 2007; Aker, 2010; Goyal, 2010; Courtois and Subervie, 2014; Nakasone et al., 2014; Aker and Fafchamps, 2015; Aker et al., 2016; World Bank, 2016). Digital innovations in our context are illustrative solutions to reduce transactions cost incurred in the exchange of goods and services in imperfect markets, particularly where they resolve problematic transaction attributes such as frequency, uncertainty, and specificity (Williamson 1975; 1985). For example, digital innovation can be designed to engage buyers and sellers in repeated transactions, mutual trust building, greater accommodation of site- and context-specificity, other relational factors that underlie market exchanges and, ultimately, contribute to reductions in the uncertainty, risk, and the costs of monitoring and enforcing each transaction in imperfect markets. Besides reducing frictions and transactions costs in existing markets, digital tools can also create new marketing mechanisms by creating demand and supply. But it is still necessary to understand the multiple pathways through which digital innovations affect these markets. To that end, in this section we review the theoretical arguments and existing empirical evidence.

First and foremost, digital innovations aim to transform the functioning of agricultural markets in Africa by improving input and output market efficiency and market integration. A number of digital market information systems and applications in the continent that aim to address various forms of market failures, including information asymmetries, are meant to fundamentally improve spatial and temporal market integration. The majority of these platforms target farmers and other upstream agents with market information on prices, quality requirements, and market outlets/destinations to improve their bargaining position.[5]

[5] While most digital tools and market information systems focus on delivering price information, some aim at delivering information on market opportunities (e.g., new or undersupplied markets), transportation options and costs,

Several empirical studies document how these types of digital tools overcome information asymmetry and reduce search costs, and ultimately improve agricultural market efficiency (e.g., Aker, 2010; Jensen, 2010; Aker and Fafchamps, 2015; Courtois and Subervie, 2014; Nakasone and Torero, 2016; Masuka et al., 2016). For example, Aker (2010) and Aker and Fafchamps (2015) show that the expansion of mobile phones reduce price dispersion in agricultural markets in Africa.[6] Andersson et al. (2017), Hernandez et al. (2017), and Belay and Ayalew (2020) show that localized price information provided by the ECX in Ethiopia reduces price dispersion and hence improve market integration. Courtois and Subervie (2014) show that a mobile-based market information system (Esoko) in Ghana led to a 10 percent increase in farmers' selling prices.

Digital solutions can also improve agricultural market performance and efficiency by matching supply and demand. These tools improve input-use efficiency by coordinating transactions, thereby improving farmers' timely access to required inputs and services. For instance, market linkage digital solutions aim to provide time-critical services that increase access to agricultural machinery and farm services. Digital platforms can create efficient new markets for machinery rental by providing more affordable access to physical capital for smallholder farmers in matching suppliers of machinery rental services with potential customers (Daum et al., 2021). A number of market linkage tools have been developed over recent years and continue to rapidly evolve in terms of scale as well as business models. They usually connect between smallholders across the value chain, including cooperatives, input producers, leasers, or distributors, on-farm service providers such as veterinarians, as well as post-harvest connections with processors, packers, buyers, traders, exporters, and other intermediaries (CTA, 2019). One successful example has been the experience of Hello Tractor in Nigeria which connects tractor owners to farmers and allows tractor owners to track their tractors (ICT Update, 2019).

Besides providing price information or matching suppliers and demanders of agricultural inputs and outputs, digital tools can improve the functioning and efficiency of agricultural markets by improving the accountability, transparency, and traceability of transactions. Most agricultural market transactions in Africa are conducted as cash exchanges in spot markets or through relational contracts (e.g., Macchiavello and Morjaria, 2021), exposing agents to a wide range of risks and

required quality or packaging standards, where storage facilities are available, critical information that can improve the coordination and functioning of agricultural markets. The latter information may expand producers'/consumers' access to new markets (usually within national borders), reduce food loss, and create new business opportunities for small agricultural producers and small- and medium sized enterprises (SMEs).

[6] Other studies show similar evidence from other Asian countries (e.g., Goyal, 2010).

transactions costs. Digital technologies can reduce monitoring costs and enable greater accountability between agents by facilitating transparency, traceability and, when necessary, opportunities to pursue recourse when a transaction fails (e.g., Grossman and Tarazi, 2014; World Bank, 2016; Fabregas et al., 2019b; Aker and Cariolle, 2020; Banerjee et al., 2020). For example, digital technologies have been shown to help farmers in Botswana meet quality and traceability requirements for exports to Europe (World Bank, 2016). Digital technologies providing financial services and transactions, including mobile money tools such as M-Pesa in Kenya, substantially address important barriers and transaction costs (e.g., Suri and Jack, 2016; Suri et al., 2021).

Digital tools can also improve value chain aggregation and formalization, where fragmentation across a given value chain is a constraint to coordination and delivery of marketing services (CTA, 2019; Malabo Montpellier Panel, 2019). Some digital tools, particularly e-platforms, can improve market coordination and efficiency by shortening supply chains in a manner that circumvents commission agents and other "middlemen" and linking producers directly to consumers, thereby creating opportunities to realize greater value among both the primary producers and consumers in the value chain. For example, Iacovone and McKenzie (2019) show that digital support tools can shorten the supply chain for fruits and vegetables by reducing the amount of time and cost for purchasing products, with important impact on venders' work-life balance and end prices for consumers. Similarly, Twiga Foods in Kenya connects smallholder farmers to vendors in cities through a mobile-based platform that guarantees higher prices to farmers while also making use of another digital tool (M-Pesa) to monitor and track transactions (Malabo Montpellier Panel, 2019).

Digital tools can also facilitate efficient use of farm inputs and services, and hence improve smallholders' marketing potential and market participation. Digital technologies are better suited than traditional extension in terms of integrating pertinent information such as soil quality and weather patterns and deliver customized/site-specific information on input use and farming practices on timely fashion.[7] Digital tools and solutions may also support with farm budgeting and bookkeeping, farm management or seasonal planning, farm operation monitoring, or for supply chain management as may be the case with larger farms, albeit these types of digital tools and

[7] Esoko in Ghana, for instance, is a digital service that started out sending farmers market price alerts via SMS and has not only grown to other countries in Africa such as Malawi, Cote d'Ivoire, Burkina Faso and Tanzania, but also grown to include additional services such as weather forecasts, agronomic advice, market linkages and insurance coverage over a range of media including SMS, voice SMS and call centers. Other examples may include weather or climate early-warning systems.

solutions are only just starting to become more available for smallholders (CTA, 2019; Birner et al, 2020).[8]

Digital agricultural tools can also improve the resilience of agricultural markets and market actors against unanticipated shocks. For example, digital tools can potentially facilitate marketing transactions in conflict-affected regions and in contexts where physical (in-person) marketing and interactions may not be feasible.[9] Or they can be used to manage idiosyncratic shocks: Suri et al. (2021) show how M-Shwari, a digital tool that facilitates digital loans, improved households' resilience to shocks in Kenya.

But the most powerful illustration comes from experiences accumulated during the lockdowns that were introduced throughout much of Africa—and the world—to contain the spread of the COVID-19 pandemic. Although these lockdowns disrupted agricultural supply chains and markets in many countries, digital tools were used in some countries to maintain critical logistical and financial services—ultimately keeping agricultural inputs and commodities moving and markets functioning (GSMA 2021, 2020; Fernando, 2020; Chakravorti et al., 2020)[10] There is already emerging evidence indicating that value chain actors that already use digital solutions in their operations were less affected by the pandemic (e.g., Abay et al., 2020).

Digital technologies can also improve data collection and dissemination, which are critical to the organization and functioning of markets as well as the policies and regulations required to ensure competition. The use of digital platforms to collect and disseminate available data on a timely basis has been identified as a golden opportunity, especially where data gaps are large, as in many parts of Africa. Big data, for example, can support tracking livestock, machinery or deliveries, and be used for monitoring and evaluation of markets and associated functionalities and forecasting various scenarios. This is more so with the advent of digital tools that utilize machine learning, cloud computing, big data analytics and the internet of things (Das Nair and Landani, 2020). There are also several examples of digital tools crowdsourcing market information from

[8] Examples of these tools include Fertimap in Morocco, AgriGo in Rwanda, BudgetMknoni in Kenya, Sen Ngunu in Senegal and AkokoTakra in Ghana. Agrivi is also an example of a more internationally available tool (CTA, 2019).

[9] However, Tkach and Williams (2018) use data from the DRC to show that some areas affected by conflict also are also characterized by connectivity or electricity constraints, which somewhat compromise this potential.

[10] The Global System for Mobile Communications Association (GSMA, 2021) report notes that with traditional extension being challenged by lockdowns and social distancing, most market advisory services shifted to digitized delivery. Farmforce in Cote d'Ivoire, Tanzania and Rwanda and Farmerline in Ghana and Cote d'Ivoire are both examples of digital tools that added COVID-19 advisory to their services (GSMA, 2020). Digital financial services have also been in high demand during the pandemic.

farmers, pastoralists, and other market actors (Alulu, 2020; Steinke et al., 2021). Most of these digital tools are meant to address specific data gaps. One such tool is Orange Garbal in Mali, which collects data and information on grazing quality and availability for livestock as well as local market prices (CTA, 2019).[11] KAZNET is another digital tool that utilizes open data software to monitor market conditions and prices for livestock products in Kenya (ILRI, 2017). Recent evaluations of the potential of these digital tools to revolutionize and substitute conventional market data collection methods show encouraging evidence (Hoogeveen and Pape, 2020; Alulu, 2020).

To sum up, our review of the theoretical and empirical evidence on the potential of digital tools to transform agricultural markets in Africa provide several reasons and justifications to remain optimist. However, most of these empirical evidence and experiences come from pilots and small-scale experiments. Despite the plethora of case studies and impact evaluations of pilot programs, there is a surprising lack of documentation on scaling experiences with digital technologies. For example, our review of the CTA (2019) documentation of agriculture-focused digital technologies in Africa indicates that most digital innovations are still at early stages of development and operate at a relatively small scale. More comprehensive assessments of tool development histories beyond the pilot stages are needed to understand where scaling efforts were attempted, how they fared and why.

3. Typology of digital tools supporting agricultural markets in Africa

The types of digital innovations aimed at supporting agricultural markets in Africa have evolved considerably in recent years. Early on, digital solutions emerged with a focus on the provision of market information via analog channels such as radio and screen displays posted in central markets. A well-known example of the latter was the network of price "tickers" set up in the mid-2000s by the Ethiopian Commodity Exchange (ECX) in district markets/headquarters across Ethiopia. Since then, digital innovations for agricultural markets in Africa have expanded and diversified across multiple dimensions. We examine four classes of such innovations below, with

[11] Another example is WeFarm in Kenya and Uganda which offers a service where farmers can ask their peers questions and they receive the response by way of the digital tool matching then to what it determines is the best suited responder (CTA, 2019).

a summary provided in Table 1 and a detailed repository of agricultural market-oriented digital tools is in Appendix 1.

The first class of digital innovations typically delivers market price information and advisories with the purpose of overcoming information asymmetries between farmers and traders, thereby improving price discovery and the distribution of gains from trade between parties. The launch of several market information systems in Africa in the early 2000s represent typical examples of market advisories and information services (Tollens, 2006). These include non-excludable public services that made relatively high-frequency price information on selected commodities widely available to farmers, traders, and other commercial actors. Examples include the Sector Information System (SIF) in Cameroon, the Agricultural Market Information Center (AMIC) in Zambia, the Livestock Market Information System (LMIS) in Kenya, and the ECX in Ethiopia, among others. This was followed by the emergence of more excludable private digital services run by commercial entities or farmers themselves, such as the Agricultural Commodity Exchange Limited (KACE) in Kenya, Esoko in Ghana, ElMofeed in Egypt and Infotrade in Uganda. These digital tools and services appear to be the most dominant types in the continent both in terms of use and coverage (CTA, 2019).

The second class of digital innovations consists of platforms that link farmers to products and services on a private (non-excludable, non-rival) basis, often with the aim to reduce the marketing or transactions costs incurred by the farmer. The products and services range from standard inputs such as seed, fertilizer, and pesticides (e.g., Kobiri in Guinea, Lersha in Ethiopia) to more novel custom-hired mechanized services (e.g., Hello Tractor in Nigeria, TroTro Tractor in Ghana) and wholesaling or retailing services (e.g., Farmster in Tanzania, Freshfarm in Egypt, Hmizate in Morocco, Agro Market Day in Uganda). Transzam in Zambia takes a slightly different approach by connecting farmers to truck drivers to facilitate transportation agricultural products (Malabo Montpellier Panel, 2019). Other examples include SafeBoda in Uganda that links farmers to markets, and AsmakNet in Egypt connects fish farms directly to markets. Although several of these innovations have revenue models based on set commission rates levied on services rendered—not unlike most digital apps—others have evolved without such revenue models, raising important questions about their long-term commercial viability.

The third class of digital innovations are services that facilitate financial transactions between value chain actors, e.g., between farmers and traders, or between aggregators and

processors. Many of these innovations aim to reduce the time, cost, and risk associated with market exchanges, similar to those in the previous class. Others aim to improve efficiency, accountability, quality assurance, and traceability through facilitating transparent transactions. There are also digital innovations that bundle financial services with other functions and services such as market information systems, farmer-to-market platforms, or extension and advisory services. Examples include financial transaction platforms such as AgriMisr in Egypt and AgroPay in Ghana, those that also offer loans such as Enda Tamweel in Tunisia and Musoni in Kenya, as well as bundled platforms like Farmcrowdy in Nigeria, Bayseddo in Senegal, Ari.farm in Somalia, SmartMoney in Tanzania, and AHMINI in Tunisia.

The fourth class of digital innovations are designed to collect agricultural market data based on crowdsourcing and remote data collection methods. While these types of tools are currently at early stages with limited functionality, they hold significant potential to revolutionize agricultural market data. These tools mostly use open-source software and crowdsourcing methods to generate high frequency and low-cost market information from various actors. These tools and services provide new opportunities to collect "big data" on markets from remote and otherwise inaccessible areas. They represent a complement or even substitute to conventional market data collection methods and have received substantial traction in fragile and remote areas (Hoogeveen and Pape, 2020). An example of this class is KAZNET, which was introduced to crowdsource livestock market information from pastoralists in Kenya (e.g., ILRI, 2017; Alulu et al., 2020). Interestingly, many of these innovations are currently designed as data extraction tools, although they can also provide feedback loops that return information to the data providers from which they crowdsource.[12]

[12] For example, few of these innovations provide customer ratings that might help farmers decide where or to whom to sell their farm production, or to provide qualitative insight into their experience with traders or buyers. An exception to this is a digital service studied by Hasanain et al. (2018) that crowds in customer ratings on artificial insemination service providers for cattle in Pakistan.

Table 1: Typology of market-oriented digital tools in African countries

Typology of digital tool	Description	Examples of solutions and functions	Examples of tools/platforms (Country)
Market Advisory and Information Services	Digitally enabled tools to deliver market information and advisories. These tools aim to address different forms of market failures that arise because of information asymmetry or increasingly high transaction costs.	• Market information systems and services (i.e., agriculture input and crop/livestock price intelligence) • Customized (precision) market advisory services • Participatory information sharing platforms (e.g., peer-to-peer) • Livestock information systems	• 80-28 Farmer Hotline (Ethiopia) • iCow (Kenya) • N'Kayo (Kenya) • Ethiopia Commodity Exchange (Ethiopia) • Farmerline's 399 Service (Ghana) • Verdant Agritech (Nigeria) • Mzar3ty (Egypt) • Mahsoly (Egypt)
Market linkages	Digital information-sharing tools to link farmers to suppliers of relevant farm inputs such as seeds or fertilizers; suppliers of production and machinery services such as tractors; or even to wholesalers/retailers.	• Supply-demand links to inputs and machinery suppliers or platform for sharing (e.g., tractors, storage) • Access and supply-demand links to markets (e.g., wholesalers)	• Hello Tractor (Nigeria) • SunCulture (Kenya) • iProcure (Kenya) • Kobiri (Guinea) • Lima Links (Zambia) • Agro Market Day (Uganda) • Freshsource (Egypt) • Tekeya (Egypt) • Hmizate (Morocco) • NINAYO (Tanzania)
Agricultural financial services and transaction	Digital services that facilitate financial and other types of transactions between agri-businesses, smallholders, and value chain intermediaries. Some of these tools aim to lower transaction costs and risks in agricultural market transactions while some others aim to improve efficiency, accountability, quality assurance and traceability of agricultural market transactions.	• Payment solutions • E-wallets and savings solutions • Traceability solutions • Quality assurance solutions • Insurance and credit solutions • Enterprise Resource Planning solutions	• Akellobanker (Uganda) • M-Pesa (Kenya) • Bayseddo (Senegal) • SmartMoney (Tanzania) • AgroPay (Ghana) • AgriMisr (Egypt) • Enda Tamweel (Tunisia) • Ari.farm (Somalia)
Agricultural market data collection and crowdsourcing services	Digital tools that can collect market data from farmers while also allowing interactions between farmers. These tools, although at early stage, create unique opportunities to collect rich data in a timely manner.	• Business-to-business fintech data analysis • Data collection and dissemination • Crowdsourcing platforms and solutions	• KAZNET (Kenya) • DigitalGreen (Multiple) • Farm.ink (Multiple) • N-frnds (Multiple) • Nuru (Kenya) • Attaisir (Morocco)

Source: Authors' compilation from different sources.

4. What explains the disconnect between pilots and scale-ups?

Although digital innovations readily lend themselves to rigorous evaluation, most studies to date have focused on identifying impacts of pilot interventions on very proximate indicators: changes in farmer awareness and knowledge about agricultural technologies and practices, subsequent uptake and adoption decisions, and profit or income effects, typically over very limited temporal and geographical scales. Few studies systematically examine market-level impacts, including impacts on input market channels, supply chain and network performance, or effects on costs, prices, and returns. The lack of nuanced evidence and experience from both successful and unsuccessful scaling efforts impedes the types of learning that may guide future scaling efforts.

This near-absence of nuanced evidence and experience relates to several factors, including the possibility that it may just be too soon, as noted earlier. But given the broad interest and enthusiasm for digital innovation in African agricultural markets, it is worth pointing out that there exists a significant gap between interesting pilot projects and successful scale-ups in Africa's digital innovation space (e.g., World Bank, 2016, Fabregas et al., 2019b; CTA, 2019; Steinke et al., 2020). In fact, the persistence of small-scale pilots in the digital innovation space combined with the limited evidence of widespread use may point to a larger challenge. It may be the case that many pilots are simply not scalable. We explore this possibility by identifying several supply- and demand-side constraints to scaling that may warrant greater attention.

Potential supply-side constraints to scaling

The first constraint to consider relates quite simply to *insufficient public and private investment* in digital innovation. Efforts to scale digital innovations to a point where they fundamentally transform African agricultural markets require considerable public investment in infrastructure and talent—investments that often have public goods attributes and thus can only be supplied by governments. At the same time, the scale-up of these innovations requires a certain degree of public sector withdrawal from the market so that input and commodity suppliers can compete and leverage digital innovations to reduce their costs and secure competitive advantages. In many countries, a statist role in price management and value chain development tends to limit these opportunities.

Meanwhile private investment in digital market-related technologies lags on the continent because of reasons such as significant initial cost, non-appropriability of added value, and long lag

times to profitability. Just as few African governments have the resources necessary to make long-term investments in soft and hard infrastructure, educational system improvements, or digital innovation incentives, few private entrepreneurs and investors have the financial capacity or risk appetite to innovate beyond a very short time-horizon. While external donors—bilateral and multilateral funding agencies, international development organizations, and charitable foundations—may have greater capacity to incubate digital innovators and invest in soft infrastructure, their own priorities and attentions often shift too quickly to stay the course.

The second constraint relates to the *asynchronous pace of change***.** Rapid progress—the oft-cited leapfrogging effect (e.g., UNCTAD 2019; Stephenson et al. 2021)—in the digital innovation space has not been accompanied by transformations in agricultural systems in many parts of Africa. In effect, the pace at which digital innovation bring solutions to agricultural markets in Africa is not being matched by changes in the rate of agricultural transformation—in productivity, capacity, or efficiency—that is needed to support and sustain these digital technologies (see, e.g., CTA, 2019). Instead, agricultural markets and transactions continue to operate in environments characterized by isolation, limited scale, and risk (Benami and Carter, 2021). In short, the absence of sufficient surplus farm production, value addition opportunities or prospects for market arbitrage may simply not yet be available in many countries and contexts.

A third constraint to scaling relates to the *embeddedness of innovation*. Ideally, digital tools and technologies perform best when they are embedded within a wider innovation process that integrates R&D with markets through knowledge brokers, financial investors, and risk-loving entrepreneurs, all within a conducive business environment and regulatory framework. This is the science of scaling, characterized by strategies in which innovations contribute to and become embedded in broader processes of systemic change (Wigboldus et al., 2016; Sartas et al., 2020; Schut et al., 2020). Instances of where all the required elements for scaling converge are still few and far between in many African agricultural markets. For example, many countries still lack comprehensive and dynamic digitalization policies or regulatory frameworks to support digital innovation in the agriculture sector. Indeed, some other countries in Africa have policies and frameworks that stifle and discourage digital innovations. A lack of clarity in regulatory

frameworks is also limiting scale up of digital innovations developed in some African countries to neighboring countries (CTA, 2019).[13]

Finally, most companies investing in digital technologies to support agricultural transformation in Africa are still struggling to develop *sustainable business models,* partly due to the incipient stage of market development (i.e., lower demand at early stage resulting to higher unit costs of service provisions). The lack of sustainable business models is limiting the reach and scale up of digital tools to support markets and marketing of agricultural products and services in Africa. Those digital innovations funded by donor organizations, in particular, are struggling to ensure a healthy balance between generating impact and financially sustaining these digital innovations. For instance, AGRA (2016) attributes the failure of many start-ups and digital innovations meant to support smallholders in Africa to the lack of viable and financially sustainable business models, partly because smallholders have limited ability and willingness to pay for digital services.

Potential demand-side constraints to scaling

The rapid resurgence of digital tools in Africa is not followed by proportional context-specific needs assessment, cost-benefit, and inclusivity analysis. Many pilots introducing digital tools lack context-specific demand analyses. In some cases, researchers aiming to revolutionize agricultural market information systems using digital innovations lack deep understanding of existing local information systems, how these systems are currently constrained and how they can be complemented or integrated with new digital innovations. In the absence of these contextual knowledge and infrastructure, new information systems end up so alien to farmers and project recipients. Because of these limitations and factors, some evaluations and willingness-to-pay analyses show that smallholders are not willing to pay the full cost of some of these innovations, either because of lack of knowledge, trust, accessibility or expected returns. For example, Cole and Fernando (2021) show that although IVR services in India increased farmer's income significantly, they are only willing to pay a fraction of that return. Similarly, whether such digital tools are sufficiently inclusive, and hence benefit marginalized smallholders, remains generally unknown, although entrepreneurs and companies are likely to target those easy to reach markets

[13] For instance, registering a transport hailing and booking platform in Ethiopia (i.e., RIDE) took some time due to the lack of appropriate regulation that can govern such types of digital solutions.

and customers (CTA, 2019). Previous studies have shown that traditional in-person agricultural and marketing service provision, including rural extension services, favor some groups of farmers (e.g., men, wealthier farmers). Whether digital tools can help circumvent these access asymmetries is not obvious, although some studies have suggested this possibility (e.g., Cole and Fernando, 2021; CTA, 2019). Ironically, digital tools may be less accessible for marginalized smallholders, including women, poorer and remotely located farmers, for whom such technologies may be more impactful. Indeed, differential access to digital innovations and associated complementary infrastructures are generating major digital divide in Africa. For example, less than 40% of smallholder households have access to internet while this increases with farm size (Mehrabi et al., 2021). Similarly, women have relatively lower access to internet and mobile phones, triggering important gender gap and digital divide ((Mehrabi et al., 2021). These alternative variants of digital divide are likely to inhibit scale up and impact of digital innovations among smallholder farmers in Africa.

The accessibility and usability of digital tools deserve more critical attention. For example, CTA (2019) shows that while registration for digital services is increasing, usage remains low. Digital literacy appears to be an important factor limiting wider usage and scale up of digital innovations. CTA (2019) documents 28 percent of digital technology enterprises report consumer-level digital literacy as an important barrier to adoption and use of digital innovations. This would also include critically examining the usability of digital tools and how they provide solutions to varying user's or user groups' abilities, recognizing that smallholders are a heterogenous group varying in "positionality" not only of their geographical location but also in terms of socioeconomic circumstances, human capital (e.g., literacy and numeracy), and social structure, even outside of formal legal or property rights (Foucault 1978:158).

User confidence in digital tools is another important, understudied area. Aker et al. (2016) highlight trust, in the sociological sense of the term, as an important element that may determine how digital tools are accepted, received, interpreted, and acted upon. Smallholders are more likely to use or rely on digital tools if they trust that the information it provides comes through a trustworthy source, is timely and high-quality and meets their needs. Perceptions about input quality has been shown to be a strong factor adoption of technologies (e.g., Michelson et al. 2021); it is entirely reasonable to assume that similar perception issues may affect user demand for information products.

5. Harnessing digital solutions in African agricultural markets: What does it take?

While there is substantial enthusiasm around the potential of digital solutions to advance inclusive and sustainable agricultural market transformations in Africa, progress made thus far has been limited to small experiments that are often donor-funded and short-lived. Reaping the full potential of digital technologies in Africa requires both the development and utilization of wide-ranging digital solutions at a meaningful scale. The first step in this direction is to address the *human capital* constraint that impedes both the creation and utilization of digital tools (Jellason et al., 2021; Birner et al., 2020; Kim et al., 2020; Malabo Montpellier Panel, 2019). The vast majority of existing digital agricultural marketing tools in the continent offer a limited range of solutions and lack novelty. This may be partly attributable to insufficient human capital in the ICT sector in Africa (CTA, 2019).[14] Thus, there is a clear need to cultivate an IT workforce with advanced ICT skills. Besides formally training large volumes of workers with ICT skills, governments can play a pivotal role by establishing innovation hubs and IT business incubators; competitive grants, innovation prize, and other incentive programs; and local tech networks that link directly to public investments in the agricultural sector.

A concurrent step is to invest in the human capital of users, especially farmers, rural entrepreneurs, and other actors who may have limited digital literacy because of age, education, gender, or opportunity. Investment in the digital literacy of users is equally important, especially among students and young farmers who may be more aware and more likely to adopt digital innovations if targeted appropriately. Further, it is important to keep in mind that even with large-scale digital literacy campaigns and education programs, many farmers may remain unfamiliar or uncomfortable with digital innovations. For example, there may be many instances where farmers prefer analog solutions such as talking to a market agent over the phone, even when the service they dial into may be digitalized on the back end. This calls for significant adaptation of digital innovations to ground realities: low levels of digital literacy among end-users, or preferences for simple and intuitive interfaces (Daum et al., 2021; Trendov et al., 2019). Examples include digital tools that integrate local in-person agents, voice recognition functions, or chat bots to help users complete lengthy registration processes or navigate complex menu options. Several of the digital

[14] A survey conducted by CTA (2019) shows that about half of the enterprises engaged in digital innovations in Africa cite insufficient human capital as a major barrier for growth.

innovations reviewed earlier integrate these strategies into their digital platforms, including Hello Tractor in Nigeria, which uses booking agents and phone calls to provide services to its clients, and Lersha in Ethiopia, which uses similarly local agents to help farmers access their digital services.

Second, there is a need for greater public and private investment in the *complementary infrastructures, both tangible and intangible,* that are required to scale digital solutions in Africa. Tangible infrastructures such as stable internet connectivity, sufficient bandwidth, wide mobile network coverage, secure server access, and electrical power are all critical to increasing the usability of the hardware and software required by these digital tools. Often, these tangible infrastructures are public goods, requiring governments to make significant investments because renumeration to private investors is either insufficient or results in inequitable distribution of benefits. Similarly, certain intangibles are needed, such as agricultural data ecosystems that integrate site-specific crops, soil, land, weather, post/disease, and market data with farmer registries. Similar to tangible infrastructures, these intangibles are often public goods given their significant initial costs, non-appropriability by private actors, long time lags to profitability, and other characteristics (Kim et al., 2020; CTA, 2019). That said, both tangible and intangible infrastructures can be procured through the public procurement of private services, public-private partnerships or other mechanisms, especially where private sector expertise and experience outweighs government capacity in the digital space—as is often the case (FAO, 2019; Baumüller, 2018).

Third, scaling digital agricultural platforms and realizing their full potential requires *innovative and sustainable business models* for private entrepreneurs in the digital space. Currently, the vast majority of digital solution providers not only rely heavily on public—particularly *donor*— funding, but actively seek public funding for their projects under the auspices of development assistance, rather than seek private funding based on credible revenue-generating models. Exceptions such as revenue models through selling subscriptions to farmers seem to be few and far between (CTA, 2019). While donor-funding can be instrumental at the pilot stage, it is unsustainable at best and, at worst, it is market distorting at the scaling stage.

Necessarily, there are strong public goods characteristics to many of the digital tools describe and categories in this review. Likewise, the market for these digital tools may be severely constrained by users' strong preferences for the status quo, their limited purchasing power, or their

ability to benefit from the non-rival and non-exclusive nature of certain tools—especially those that can contribute to the broader productivity or welfare of a community beyond the individual user (Hidrobo et al., 2020; Birner et al., 2021; Fabregas et al., 2019a). Thus, public funding continues to be crucial in the early stages of services like the 80-28 IVR Hotline in Ethiopia or NamLITS in Namibia.

But the persistence of market distortions induced by public (and donor) funding suggests a need for these funding agencies to quickly push digital providers towards clear business models and profitability pathways. And, if they cannot, then they should walk away from such projects and invest in more traditional public goods projects that remain critical to agricultural market development. One such pathway to profitability may be the bundling of public goods and services with fee-for-use services. This type of business model has considerable potential since sellers of farm inputs can be profitable by selling multiple, complementary products while also covering their costs of information creation and distribution. The same goes for buyers of outputs in commodity markets. An example of this approach is Xarvio™ – Digital Farming Solutions, in which an input provider finances a sophisticated digital platform that serves both farmers and contractors; or DigiFarm and iCow in Kenya, which are financed by network providers who have an incentive to increase subscribers and ensure customer loyalty in addition to providing agriculture market-related services. The absence of commercially viable bundled services may be attributable to the costs and complexity it entails: fully functional, digitally integrated services are a much more significant investment than a simple app that matches buyers with sellers. Unfortunately, the digital ecosystem in much of Africa currently favors simple apps and adaptive innovation over complex commercial solutions that require novel and intense design processes, though that may be changing rapidly.

Fourth, countries in Africa must also develop *complementary agricultural inputs markets and services* in order to make the information/services provided by digital platforms actionable. Development of complementary input and output markets is in fact a peculiar problem that countries in African must address to keep the traction of digital agricultural tools/solutions and create greater momentum. This is because most digital agricultural tools in Africa aims to promote efficient use of inputs and provision of market information, and the values of these information/services will be very limited in the absence of well-developed input and output markets. Possibly, the digital platforms themselves can also support this process through

integrating functions that can facilitate the matching of demand with supply in agricultural input markets.

Fifth, creation of *dynamic policies and smart regulations* that can spur digital innovations as well as safeguard the competitive process, equitable distribution of digital dividends, address privacy concerns, and promote good data stewardship are essential (Kira et al., 2021). Currently, countries with a dedicated policy for agricultural digitization are scarce in the continent and or fall short at the implementation stage, thus limiting the production, distribution, and uptake of digital technologies and services (Ayamga et al., 2021, Tossou et al., 2020; Korovkin, 2019; Nakasone and Torero, 2016). Moreover, policies need to embrace digital solutions beyond individual projects and create institutional space for flexible and data-driven decision making (Steinke et al., 2020). Regularly updating digital polices to keep pace with the dynamic needs of the digital ecosystems is also equally important.

Last but not the least, countries should deliberately facilitate the creation of *strong alliance among digital actors*. Existing digital initiatives are fragmented in most countries and results in under-utilization of complementarities/synergies and sometimes lead to duplication of efforts. A well-coordinated partnership among digital actors (including user representatives) will facilitate investments, innovations, collaborations (Kim et al., 2020). Such alliance will be also instrumental in cost-effectively developing shared infrastructures such as agricultural data ecosystem that can be used across actors/geographies (CTA, 2019). Another potential point of collaborative effort would be to agree on standard ontologies for data collection that could facilitate pooling of data collected across platforms. That said, care should be taken to preserve the competitive features of the marketplace, under which the quality and efficiency of service provision is most likely to improve as a function of market forces.

6. Encouraging trends and emerging risks

Already, there are encouraging trends suggesting that many of the right steps are being taken across Africa to encourage digital innovation in agricultural markets. Ecosystems of small start-up enterprises are emerging in multiple countries, and governments are easing restrictions on the movement of talent from the African diaspora and between African countries to facilitate these enterprises. In several countries, tech incubators and developer hubs appear to be thriving (e.g.,

Kenya's Silicon Savannah, Nigeria's Wennovation Hub, South Africa's Silicon Cape Initiative).[15] Meanwhile, many of the necessary infrastructure investments are being made, albeit within the limits of public budgets that are stretched thin across multiple development priorities. Partly as a result of these investments, growth in Africa's digital connectivity is expected to continue to increase dramatically in coming years, giving increasing scope for economies of scale in service provision.[16]

However, there remain certain types of constraints that are not easy to overcome by strategic investments in human capital, infrastructure, and policy reforms. The most significant among these may not be the dispersed and fragmented nature of smallholder agriculture, but rather the persistence of non-competitive market structures and the unequal distribution of market power. Monopsony and monopoly market structures are a common historical feature in agriculture throughout much of the world: state-owned enterprises, commodity boards, colonial-era export monopolies, and other anti-competitive institutions were ubiquitous in agricultural markets during Africa's early stages of development in the post-colonial era. Traders, middlemen, and commission agents—often part and parcel of these same anti-competitive institutions—were also positioned to exert market power over smallholders due to higher financial abilities or in situations of oligopsony or monopsony.

Today, new forces may be sustaining or even expanding these anti-competitive forces as new forms of political capture and rent seeking enable anti-competitive strategic behavior across multiple value chains. It remains to be seen whether digital innovations can push markets towards greater competition by, for example, improving farmers' access to information about price trends, their outside options in less-than-favorable obligations under formal or relational contracts. In fact, it may be the case that digital innovations have no value in instances where powerful actors can prevent their adoption, or when those same actors can simply dictate terms to farmers irrespective of the information or services offered by the digital innovation. And even those disruptive innovations with the potential to shake the very foundations of a captured market—something similar to, say, ride-sharing apps that threatened the market power of public transport regulators,

[15] Increasingly, there is an explicit focus on agriculture within these initiatives. For example, Nigeria's Wennovation hub recently launched an incubation program which provides training and mentorship to agri-tech startups.

[16] For example, in sub-Saharan Africa, between 2020 and 2025 the percentage of households with SIM connections is expected to rise from 77% to 90%, and smart phone adoption is expected to increase from 48% to 64% (GSMA 2021b).

taxi monopolies, and driver unions in some industrialized countries—are unlikely to survive when political force is brought down on their business plan.

When agricultural markets are non-competitive and when powerful forces have outsized influence over both the agricultural sector and digital space, there is also a potential threat to privacy. Farmer registries—mentioned earlier as a potentially essential part of a functional digital ecosystem—are also control systems for many governments. With information on a farm-household's demographic profile, landholdings, assets ownership, crop mix, and other characteristics—governments are well-positioned to dictate production and marketing decisions that may be beneficial to national food security or export promotion strategies, but unprofitable for the individual farmer. In effect, the collection and use of personal data can encourage the latent tendencies of government toward central planning that ultimately rob farmers and other value chain actors of making decisions in their own best interest. This is not a benign threat: already, some governments throughout Africa have made considerable strides in this direction with support from donors, the private sector, and other entities.

Another point that merits some discussion is the need for some kinds of tools to achieve a critical mass in user participation to enable their services to flourish and sustain. As an example, applications which connect buyers and sellers will not work well without a sufficient number of potential transacting partner options: if options are too thin, price signaling may be muted, and transaction characteristics (in terms of location, volume, quality standards, etc.) may be too limited to be attractive to either buyers or sellers. But growing sufficient volume may be difficult in early stages of market development. It is not clear what public support strategies may help overcome these hurdles without compromising competitive market characteristics.

7. Conclusion

A great deal has been said in recent years about the potential for digital tools to transform agricultural marketing in Africa. In particular, the theoretical potential of ICT to overcome information asymmetries, coordination failures and other limitations of thin and spatially dispersed agricultural markets has motivated considerable investments in market-oriented tool development. However, empirically-grounded discussion of the performance and scaling experiences of ICT-enabled agricultural marketing tools has been limited to date. In this article, we have synthesized

the existing evidence around the characteristics of ICT-enabled marketing tools, their deployment and efforts to scale.

A major conclusion of our review is that, while many agricultural marketing tools have been developed and deployed in recent years in Africa, the vast majority of these have been implemented at pilot stages, with limited evidence of successful scaling. There is a strong need to systematically capture scaling experiences – including failures – in order to better understand the critical features of viable scaling strategies in different contexts. The current lack of nuanced evidence from both successful and unsuccessful scaling efforts around agriculture-focused digital tools in Africa is impeding learning which may guide future scaling efforts. Relatedly, evaluations of tool impacts will require not only measurement of changes in farmers' knowledge, technology adoption patterns, or productivity outcomes – as is typically the case in program evaluation efforts – but also longer-term and broader market-level impacts, such as value creation and value chain efficiencies, as well as higher-order impacts related to welfare and equality. In other words, internal validity concerns should not obscure the need for studies with plausible external validity.

A second major takeaway from our analysis is that the marketing and related institutional characteristics of Africa pose some important constraints for the development of agricultural marketing tools. Non-competitive market structures and the unequal distribution of market power remain prevalent characteristics in much of the region. The rapid roll out of digital marketing innovations has outpaced infrastructural and institutional change in most of the region. Without committed policy attention to improved business environments, digitalization policies, and regulatory frameworks, the scope for private-sector-led expansion of digital tools will likely remain limited.

A third and important stylized pattern we observe is the differential progresses African countries in tapping the potential of digital tools as well as differential access to digital innovations across communities and households. While some African countries have made significant stride in their digital space (e.g., Kenya), weak internet infrastructure and regulatory frameworks in many African countries will likely continue to inhibit widespread scale up of digital innovations in the next few years. Furthermore, our synthesis shows that the differential access to internet and mobile phones across genders and small and larger farm households are triggering alternative variants of digital divide (e.g., Mehrabi et al., 2021). This necessitates investments and policies to ensure digital inclusion of marginalized households and communities.

Our analysis can be taken as a gentle corrective to the sometimes-unbridled enthusiasm that has accompanied the advent of digital agriculture in Africa. Importantly, however, our assessment of the current situation is still consistent with a fundamentally optimistic view of the possibilities for ICT-enabled digital tools to support transformative change in Africa's agricultural markets. The challenges we highlight are all surmountable. However, policy reforms and investments should be informed by careful analysis of what works, in turn enabled by better data collection on the innovations now in the field. This implies, at minimum, better coordination amongst national governments, donors, and project partners, to more systematically generate and pool comparable information about scaling efforts. The potential payoff to such efforts, however, may be considerable, i.e., faster and more efficient scaling of marketing tools that can significantly improve the livelihoods of Africa's smallholder farmers.

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Appendix 1: Inventory of Digital Agriculture Tools

Service Type Description & Evolution	Examples of solutions and functions	Examples of Tools/Platforms	Country scope
Market Advisory and Information Services			
Digitally enabled tools to deliver market information and advisories. These tools aim to address different forms of market failures that arise because of information asymmetry or increasingly high transaction costs.	• Market information systems and services (i.e., agriculture input and crop/livestock price intelligence) • Customized (precision) market advisory services • Participatory information sharing platforms (e.g., peer-to-peer) • Livestock information systems	SIF	Cameroon
		Agri Conseil	Cote d'Ivoire
		Lor Bouor	Cote d'Ivoire
		Rice Advice	Cote d'Ivoire
		AgriDB	Egypt
		AlMorshed for Poultry	Egypt
		AlNota	Egypt
		AsmakNet	Egypt
		Baramoda	Egypt
		ElZeraa ElYoum	Egypt
		Erdeb	Egypt
		Hudhud	Egypt
		IRWI	Egypt
		Mahsoly	Egypt
		Mazra3ty	Egypt
		Shary	Egypt
		Vodafone / Egyptian Farmers	Egypt
		Wastilizer	Egypt
		80-28 Farmer Hotline	Ethiopia
		Ethiopia Commodity Exchange (ECX)	Ethiopia
		AkokoTakra	Ghana
		Esoko	Ghana
		Farmerline's 399 Service	Ghana
		Arifu	Kenya
		BudgetMknoni	Kenya
		DigiCow	Kenya
		iCow	Kenya
		iShamba	Kenya
		KARLO	Kenya

Service Type Description & Evolution	Examples of solutions and functions	Examples of Tools/Platforms	Country scope
		Kenya Agricultural Commodicty Exchange (KACE)	Kenya
		M-Kilimo	Kenya
		SmartCow	Kenya
		CLIMARK	Kenya; Ethiopia
		Weather Impact	Kenya; Ethiopia; Burundi; South Africa
		WeFarm	Kenya; Uganda
		Mlimi Hotline	Malawi
		OMA	Mali
		AGROAM	Morocco
		Attaisir	Morocco
		Crop Growth Monitoring System	Morocco
		Agrivi	Multiple
		Agrocares	Multiple
		Agrospaces	Multiple
		Awaaz.De	Multiple
		Digital Green	Multiple
		EngageSpark	Multiple
		Farm Ink	Multiple
		N-Frnds	Multiple
		Orange	Multiple
		PlantMed	Multiple
		Viamo 3-2-1	Multiple
		WhatsApp	Multiple
		NamLITS	Namibia
		Probity Farms	Nigeria
		SmartFarm	Nigeria
		Verdant Agritech	Nigeria
		AgriGo	Rwanda
		AgriProFocus Rwanda	Rwanda
		SNS	Rwanda
		Sen Ngunu	Senegal

Service Type Description & Evolution	Examples of solutions and functions	Examples of Tools/Platforms	Country scope
		Al Waha farm	Sudan
		DAL	Sudan
		Tigi Kilimo	Tanzania
		Institut National des Grandes Cultures	Tunisia
		CKW	Uganda
		Infotrade	Uganda
		N'Kayo	West Africa
		AgriPredict	Zambia
		AMIC	Zambia
		EcoFarmer	Zambia
		Ziamis	Zambia
Market Linkages			
Digitally enabled tools to deliver market information and advisories. These tools aim to address different forms of market failures that arise because of information asymmetry or increasingly high transaction costs.	• Supply-demand links to inputs and machinery suppliers or platform for sharing (e.g., tractors, storage) • Access and supply-demand links to markets (e.g., wholesalers)	Jinukun	Benin
		Premium Hortus	Benin
		efarm.cm	Cameroon
		Jangolo	Cameroon
		MobiGrow	East Africa
		AgriDB	Egypt
		Agrimisr	Egypt
		AlMorshed for Poultry	Egypt
		AsmakNet	Egypt
		Bashaier	Egypt
		ElMofeed	Egypt
		ElZeraa ElYoum	Egypt
		Erdeb	Egypt
		Freshfarm	Egypt
		Freshsource	Egypt
		HudHud	Egypt
		Mahsoly	Egypt
		Mazra3ty	Egypt
		Ragab ElAttar	Egypt
		Shary	Egypt

Service Type Description & Evolution	Examples of solutions and functions	Examples of Tools/Platforms	Country scope
		Tekeya	Egypt
		Lersha	Ethiopia
		agrotrade	Ghana
		CowTribe	Ghana
		Farmart	Ghana
		Farmerline	Ghana
		FarmFresh	Ghana
		Trade	Ghana
		TroTro Tractor	Ghana
		Kobiri	Guinea
		DigiFarm	Kenya
		E-Tinga	Kenya
		FarmAll	Kenya
		Farmers Pride	Kenya
		FarmIT	Kenya
		Farmshine	Kenya
		Herdy Fresh	Kenya
		Kitchen Soko	Kenya
		Mifugotrade	Kenya
		Rubi	Kenya
		Selina Wamuchi	Kenya
		SunCulture	Kenya
		taimba	Kenya
		TruTrade	Kenya
		Tulaa	Kenya
		Twiga Foods	Kenya
		Farm to Market Alliance	Kenya, Rwanda, Tanzania, Zambia
		Agrics	Kenya; Tanzania
		iProcure	Kenya; Tanzania
		Mastercard's Farmers Network	Kenya; Tanzania; Uganda
		VirtualCity	Kenya?

Service Type Description & Evolution	Examples of solutions and functions	Examples of Tools/Platforms	Country scope
		myAgro	Mali; Senegal
		Hmizate	Morocco
		izyshop	Mozambique
		Azuri	Multiple
		Eprod	Multiple
		FarmForce	Multiple
		Jumia	Multiple
		Logistimo	Multiple
		Loop	Multiple
		Metajua	Multiple
		M-Shamba	Multiple
		One Acre Fund	Multiple
		Simusolar	Multiple
		SourceMap	Multiple
		SourceTrace	Multiple
		WeightCapture	Multiple
		Afrimash	Nigeria
		Babban Gona	Nigeria
		Foodstocks Farmers Market	Nigeria
		Hello Tractor	Nigeria
		village market	Nigeria
		zowasel	Nigeria
		Get It Rwanda	Rwanda
		HMart	Rwanda
		Mkulima Young	Rwanda
		Khula	South Africa
		Nafeer	Sudan
		Farmster	Tanzania
		Ninayo	Tanzania
		Trringo	Tanzania
		Herundo	Tunisia
		Agro Market Day	Uganda
		EzyAgric	Uganda

Service Type Description & Evolution	Examples of solutions and functions	Examples of Tools/Platforms	Country scope
		Safe Boda	Uganda
		eMsika	Zambia
		Lima Links	Zambia
		Tanszam	Zambia
Agricultural Financial Access and Transaction			
Digital services that facilitate financial and other types of transactions between agri-businesses, smallholders, and value chain intermediaries. Some of these tools aim to lower transaction costs and risks in agricultural market transactions while some others aim to improve efficiency, accountability, quality assurance and traceability of agricultural market transactions.	• Payment solutions • E-wallets and savings solutions • Traceability solutions • Quality assurance solutions • Insurance and credit solutions • Enterprise Resource Planning solutions	Advans`	Cote d'Ivoire
		Cocoblock	Cote d'Ivoire
		Djori	Cote d'Ivoire
		INVESTIV	Cote d'Ivoire
		Moov	Cote d'Ivoire
		MTN	Cote d'Ivoire
		Orange	Cote d'Ivoire
		AgriMisr	Egypt
		AgroPay	Ghana
		Apollo Agriculture	Kenya
		M'Pesa	Kenya
		M'Shwari	Kenya
		Musoni	Kenya
		Tulaa	Kenya
		Credit Agricole du Maroc	Morocco
		Farmcrowdy	Nigeria
		Growsel	Nigeria
		Thrive Agric	Nigeria
		Bayseddo	Senegal
		Ari.farm	Somalia
		Livestock Wealth	South Africa
		SmartMoney	Tanzania
		AHMINI	Tunisia
		Enda Tamweel	Tunisia
		Akellobanker	Uganda
		Zoona	Zambia

Service Type Description & Evolution	Examples of solutions and functions	Examples of Tools/Platforms	Country scope
Agricultural Market Data Collection and Crowdsourcing Services			
Digital tools that can collect market data from farmers while also allowing interactions between farmers. These tools, although at early stage, create unique opportunities to collect rich data in a timely manner.	• Business-to-business fintech data analysis • Data collection and dissemination • Crowdsourcing platforms and solutions	Agrospaces	Cameroon
		KAZNET	Kenya
		Nuru	Kenya
		Orange Garbal	Mali
		AgriKaab	Multiple
		Complete Farmer	Multiple
		DigitalGreen	Multiple
		Farm.ink	Multiple
		N-frnds	Multiple
		PULA	Rwanda
		SarVision	Rwanda
		GeoAgro Pro	Egypt
		Verumcode	Egypt
		AgriEdge	Morocco
		Attaisir	Morocco