

THE DIGITALISATION OF AFRICAN AGRICULTURE REPORT

2018-2019



Dalberg Advisors



**THE
DIGITALISATION
OF AFRICAN
AGRICULTURE
REPORT**

2018-2019

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Digitalisation is crumbling all sorts of borders and African agriculture will be deeply impacted. Technologies can help stimulate innovation for sustainable agri-food systems and produce better and safer food while preserving natural resources and biodiversity. But we need to be conscious and support solutions that are sustainable and that are tailored to countries' needs, and embedded into conducive and broader innovation systems. This is in line with the EU's Digital4Development and SDGs agendas that we are proudly promoting. ”

Leonard Mizzi
Head of Unit at the European Commission,
Directorate-General (DG) for International
Cooperation and Development

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GLOSSARY

Active use

Use of a digital solution frequently enough to obtain or even maximise its target benefits.

Addressable market

The potential revenue size of the market that can be addressed by existing solutions.

Advisory and information services

Digitally delivered information on topics such as agronomic best practices, pests and diseases, weather, and market prices, as well as more sophisticated digital services and farm management software tailored to the specific farmer, farm, or field that enable smallholder farmers to make decisions that maximise output from their land, improve the quality of agricultural production, and maximise farm revenues and profits via lower costs of production, improved ability to identify markets, and/or better price realisation.

Agribusiness

Businesses collectively associated with the production, processing, and distribution of agricultural products, including business entities involved in the production and distribution of agricultural inputs and machinery to farmers and those involved in purchasing, aggregating, processing, and distributing farm produce.

Agricultural transformation

A state in which agriculture is a vibrant, modern, and sustainable business that creates value for farmers, entrepreneurs, youth, and women, and produces affordable, nutritious, and healthy food for all.

Artificial intelligence (AI)

AI is defined as the ability of machines and systems to acquire and apply knowledge, and to carry out intelligent behaviour.

Big data

Large, diverse, complex data sets generated from instruments, sensors, financial transactions, social media, and other digital means, and typically beyond the storage capacity and processing power of personal computers and basic analytical software..

Big tech

Big multi-national hardware, software, and social media companies like Google, Microsoft, Alibaba, IBM, and SAP.

Blockchain

A digital database containing information such as records of individuals, land, and financial transactions that can be simultaneously used and shared within a large decentralised, publicly accessible network ('distributed ledger') and memorializes transactions between parties efficiently and in a verifiable and permanent way.

Bundling

Marketing and distribution strategy that joins multiple products or services together to sell them as a single combined unit in order to deliver more value to consumers and/or more economic benefits to the business offering the products; in the context of this report, refers specifically to solutions that cover two or more D4Ag use cases.

Climate resilience

Climate resilience is the ability to prevent climate-related disasters and crises as well as to anticipate, absorb, accommodate or recover from them in a timely, efficient and sustainable manner. This includes protecting, restoring and improving food and agricultural systems under climate threats that impact food and nutrition security, agriculture, and food safety/public health.

Climate-smart agriculture

Climate-smart agriculture is an approach for transforming and reorienting agricultural production systems and food value chains so that they support sustainable development and can ensure food security under climate change.

Crowd-farming

Crowd-farming uses digital platforms to link farmers who need capital with sponsors who wish to invest; a form of 'crowd-sourced' financing in the agriculture context.

Data infrastructure

Data collection and analytics tools and systems, as well as the resulting data assets (e.g., farmer registry, land registry, soil, pest and disease databases) that are relevant to smallholder farmers and/or those who work with them.



Digitalisation for agriculture (D4Ag)

Digitalisation for agriculture (D4Ag) is the use of digital technologies, innovations, and data to transform business models and practices across the agricultural value chain and address bottlenecks in, *inter alia*, productivity, postharvest handling, market access, finance, and supply chain management so as to achieve greater income for smallholder farmers, improve food and nutrition security, build climate resilience and expand inclusion of youth and women.

Drone

Remote-controlled pilotless aircraft that have many applications for agriculture field surveillance and remote diagnostics of agronomic conditions such as plant and crop diseases, water resources, and soil quality.

Engaged user

Farmers who are registered for digital solutions and use them to some extent, but not necessarily to the level that could be called active or intensive use. Also see 'Active use'.

Enterprise resource planning (ERP)

Software that digitalises and helps manage and integrate core business processes like supply chain operations, logistics, reporting, financial tracking, and human resource activities.

Extension

An agricultural extension service offers technical advice on agriculture to farmers, and also supplies them with the necessary inputs and services to support their agricultural production.

Farmer information services (FIS)

Services that provide more general advisory information on agronomic best practices (e.g., growing, harvesting, post-harvest treatment, storage, inputs, and market prices) without tailoring the recommendations beyond national, value chain, or district levels.

Financial access

Digital financial services (DFS) relevant for smallholder farmers, such as digital payments, savings, smallholder credit, and agricultural insurance, which increase financial access and equip smallholder farmers to improve yields and incomes and invest in the longer-term growth of their farms.

Financial service provider (FSP)

Enterprises engaged in the delivery of financial services and products including commercial banks, insurers, payments companies, microfinance institutions (MFIs) and savings and credit cooperative organisations (SACCOs).

Fintech

Enterprise(s) in the financial sector that either provide financial services to consumers directly by making use of software and digital communication channels or utilize digital technologies to deliver business-to-business services to financial service providers.

Geodata

Information about a geographical location held in a digital format; also called geospatial data and information, georeferenced data and information, as well as geoinformation.

Geo-referencing

Adding coordinate information to a digital image such as a scanned map to enable the mapping software to match the map with its real-world location.

Global positioning system (GPS)

System showing the exact position of an object on earth using satellite signals.

Information communication technology for agriculture (ICT4Ag)

Use of Information and Communication Technologies (ICTs) in the agricultural sector. In this report we distinguish between ICT4Ag approaches that have characterised earlier efforts to digitalise African agriculture from the new D4Ag era which involves a broader set of digital tools (i.e., machine learning, big data analytics, Internet of Things), wider array of use cases, and a distinctly more commercial and market-based focus for business models.

Internet of things (IoT)

System in which devices including mobile phones, sensors, drones, and satellites, are connected to the internet.

Machine learning

Giving computers the ability to learn through analysis of big data.



Macro agricultural intelligence

Data analytics solutions and digital decision support tools that integrate a variety of data sources on smallholder farmers, farms, and markets and convert this information into useful country- and value-chain-level insights and decision tools for government policymakers, extension agencies, agronomists, agribusinesses, and investors.

Market aggregation

Undifferentiated marketing where consumers are treated as a single group.

Market linkages

Digitally-enabled solutions that link smallholder farmers to high-quality farm inputs (e.g., seeds, fertilisers, herbicides/pesticides), to production and post-harvest machinery and mechanisation services (e.g., irrigation, tractors, cold storage), or to off-take markets, including agro-dealers, wholesalers, retailers, or even to the end-consumer.

Market penetration

The share of the market that is being reached by a product or a service, typically computed as a share of a total population or share of total market economic value (e.g., share of sector revenues or profits). Also see 'Addressable market'.

Mechanisation access services

Digital solutions that extend farmer access to agricultural machinery or mechanised farm services (e.g., irrigation, tractors, cold storage).

D4Ag infrastructure/middleware infrastructure

D4Ag infrastructure (also sometimes referred to as D4Ag 'middleware' infrastructure) includes agriculture sector specific data, hardware, and software infrastructure that D4Ag solutions rely on to source information and deliver their services to farmers and other agriculture intermediaries; these are the building blocks that D4Ag solutions use to do what they do. Also see 'Data infrastructure'.

Pastoralists

Those whose primary occupation is extensive grazing on rangelands for livestock production; distinct from agro-pastoralists, whose livelihoods depends on both livestock production and land-based agricultural cultivation, and who are typically included within the smallholder farmer definition.

Pay-as-you-go (PAYG)

Digitally-enabled business models in which services are paid for remotely with small, frequent payments such as daily or weekly installments, and where the product (e.g., off-grid solar water irrigation pump) can be remotely deactivated or blocked in the case of non-payment.

Precision agriculture advisory

Precision advisory services represent a move from generalised best practices to recommendations tailored to individual agroclimatic conditions (e.g., weather, soil, etc.), crop varieties, and the economic setting of the farm (e.g., input prices, market prices, and market distances).

Registrations

Registrations refer to farmers enrolling in or signing up for D4Ag solutions. The form of registration depends on the type of solution.

Remote sensing

Process of gathering information about objects on earth from a distance using aircraft or satellites.

Satellite imaging

Images of earth collected by satellites.

Smallholder farmers

Individuals who produce crops or livestock on two or fewer hectares of land. Technically speaking this term only includes farmers and agro-pastoralists who are tied to specific pieces of farmland, but this report uses the term more generally to refer to small farmers, agro-pastoralists, and nomadic pastoralists.

Software-as-a-service (SAAS)

Services that can be accessed via the internet rather than through downloading and installing software.



Soil mapping

The process of identifying, capturing and depicting soil properties and distribution on a map.

Super platform

Type of D4Ag solution which bundles together multiple different services for farmers or other smallholder value chain intermediaries and, typically, integrates digital market linkage services, advisory services, and financial services, among others.

Supply chain management

Digital supply chain management solutions are business-to-business services that help agribusinesses, cooperatives, nucleus farms, input agro-dealers, and other smallholder farmer value chain intermediaries to manage their smallholder relationships.

Pest and disease surveillance

Monitoring at regional, national, or even farm and field levels to record the prevalence and severity of pests and plant diseases; typically goes beyond simple monitoring to include early warning and advice on pest and disease management.

Weather and climate infrastructure

Physical (e.g., weather base stations) and digital infrastructure for collecting and recording data on climatic conditions and weather at various levels of geographic granularity, from regional weather patterns down to the agroclimatic conditions (e.g., level of precipitation and temperature) for a farm or specific farm field.

Unmanned aerial vehicle (UAV)

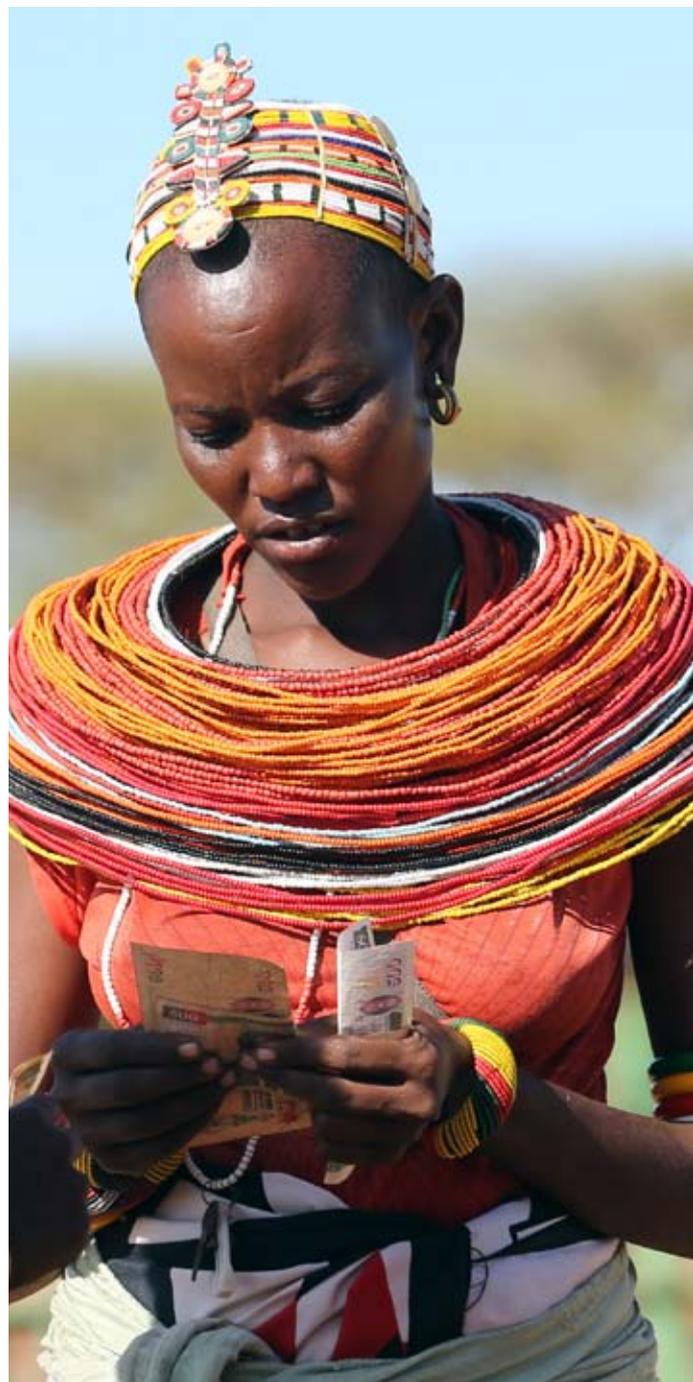
Aircraft that carry no human pilot or passengers. Also see 'drone'.

Unstructured supplementary service data (USSD)

A global system for mobile (GSM) technology in which a user can send messages between a mobile phone and an application programme, including prepaid roaming and mobile chatting, in the network.

Weather index-based insurance

Agricultural insurance that uses a weather index such as rainfall to determine pay-outs, thus allowing the system to manage weather and climate risk.



Fredrick Omondi, CTA



ABBREVIATIONS AND ACRONYMS

ACRE Africa	Agriculture and Climate Risk Enterprise	CGAP	Consultative Group to Assist the Poorest
AfCFTA	African Continental Free Trade Area	CGIAR	Consortium of International Agricultural Research Centres
AfDB	African Development Bank	CSA	climate-smart agriculture
AfSIS	Africa Soil Information Services	CTA	Technical Centre for Agricultural and Rural Cooperation
API	application programming interface	CTIC	Conservation Technology Information Centre
ARPU	average revenue per user	D4Ag	digitalisation for agriculture
ATA	Agricultural Transformation Agency (Ethiopia)	DRC	Democratic Republic of Congo
BMGF	Bill and Melinda Gates Foundation	DSG	digital savings group
BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit (German Federal Ministry for Economic Development Cooperation)	ERP	enterprise resource planning
CAGR	compound annual growth rate	ESIPPS	Environmental Surveys, Information, Planning and Policy



eWTP	Electronic World Trade Platform	LMIC	low- and middle-income country
FAO	Food and Agriculture Organization of the United Nations	MFI	microfinance institution
FSP	financial service provider	MNO	mobile network operator
FiMA	Farm to Market Alliance	MUIIS	market-led user-owned ICT4Ag-enabled information service in Uganda
G4AW	Geodata for Agriculture and Water of the Dutch Ministry of Foreign Affairs	MPCI	multi-peril crop insurance
GDP	gross domestic product	NAERLS	National Agricultural Extension and Research Liaison Service (Nigeria)
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit	OECD	Organization for Economic Cooperation and Development
GODAN	Global Open Data For Agriculture and Nutrition	PE	private equity
GPSDD	Global Partnership for Sustainable Development Data	PFJ	Planting for Food and Jobs
GSMA	Global System for Mobile Communications Association	PIP	Priority Investment Program
HH	household	ROSCA	rotating savings and credit association
IBRD	The International Bank for Reconstruction and Development	SAAS	software as a service
ICT	information and communication technology	SACCO	savings and credit cooperative organisation
ICT4Ag	information and communication technology for agriculture	SARL	société anonyme à responsabilité limitée
IFC	International Finance Corporation	SDG	Sustainable Development Goal (UN)
IFPRI	International Food Policy Research Institute	SDS	security and development strategy
ILRI	International Livestock Research Institute	SFSA	Syngenta Foundation for Sustainable Agriculture
IoT	Internet of things	SHF	smallholder farmer
iSDA	Innovative Solutions for Decision Agriculture	SMS/IVR	short message service/interactive voice response
ISF	Initiative for Smallholder Finance	SNS	Smart Nkunganire System (Rwanda)
ISRIC	International Soil Reference and Information Centre	TAM	total addressable market
IVR	interactive voice response	UAV	Unmanned aerial vehicle (i.e., 'drones')
KALRO	Kenya's Agriculture and Livestock Research Organisation	UCFA	Uganda Coffee Farmers Alliance
KAOP	Kenya Agriculture Observatory Platform	UN	United Nations
KPI	key performance indicator	USAID	United States Agency for International Development
KPOGT	Kalangala Palm Oil Grower's Trust	USSD	unstructured supplementary service data
		VAS	value-added service
		VC	venture capital
		VSLA	village savings and loan association



FOREWORD



CTA

Michael Hailu, Director, CTA

Agricultural transformation is a priority in the policy agenda of African governments in their quest to meet the challenges of food and nutrition insecurity, climate change, youth unemployment and overall economic growth. With the right policies, innovation and investment, the continent's agriculture could be transformed into a powerhouse not only to feed a growing population but to create decent employment for millions of young people.

Technology, as we have seen in other sectors, is critical to affecting change and driving development. It is bringing countries closer together, reducing barriers to trade and offering a window of opportunity to 'digital native' youth entrepreneurs at the vanguard of innovation applied to different economic sectors. In agriculture, digitalisation could be a game changer in boosting productivity, profitability and resilience to climate change.

An inclusive, digitally-enabled agricultural transformation could help achieve meaningful livelihood improvements

for Africa's smallholder farmers and pastoralists. It could drive greater engagement in agriculture from women and youth and create employment opportunities along the value chain.

There has been significant growth in digitalisation for agriculture (D4Ag) over the last ten years. In 2019 both the European Union-African Union Task Force Rural Africa Report (TFRA) and the Communiqué from the Global Forum for Food and Agriculture (GFFA) highlighted the power of digitalisation in transforming agriculture.

However, despite growth, progress towards D4Ag has been somewhat slow to serve the smallholders that produce 80% of Africa's agricultural output. Nevertheless, the opportunity is there. Agriculture is expected to be a trillion-dollar market by 2030, ripe for innovation that will drive greater efficiency, sustainable increases in productivity, yield and income.

At CTA we staked a claim on this power of digitalisation to more systematically transform agriculture early on. Digitalisation, focusing on not individual ICTs but the application of these technologies to entire value chains, is a theme that cuts across all of our work. In youth entrepreneurship, we are fostering a new breed of young ICT 'agripreneurs'. In climate-smart agriculture multiple projects provide information that can help towards building resilience for smallholder farmers. And in women empowerment we are supporting digital platforms to drive greater inclusion for women entrepreneurs in agricultural value chains.

In other words, at CTA, we know and understand the power to digitalise African agriculture. But we also understand that the evidence that will attract targeted investments to further develop D4Ag on the continent is lacking.

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With the right policies, innovation and investment, the continent's agriculture could be transformed into a powerhouse not only to feed a growing population but to create decent employment for millions of young people. ”



“

And as long as we learn from lessons, do it right and manage risks and take into account data sovereignty, inclusivity, sustainability, we will all benefit.”

We realised that it is time to chart the scale of the opportunity and make some projections that will help in guiding policy and investment decisions. It is why we have produced this report together with Dalberg Advisors and supported by a high-level Advisory Council bringing together the key stakeholders that have been engaged in the space. The report is the first attempt to consolidate evidence and provide proof of impacts and the knowledge that will allow evidence-based investments.

While, in the report, we find a young sector, it's clear that the appetite for D4Ag is burgeoning. However, without the right policy focus and investment there is a danger that the development will be piecemeal, neither sustainable nor inclusive. To capitalise on this opportunity we need to ensure that development is coordinated, that best-practices are shared and a collaborative approach to rolling out and scaling-up digital innovation, primarily focused on increasing use by farmers, is adopted.

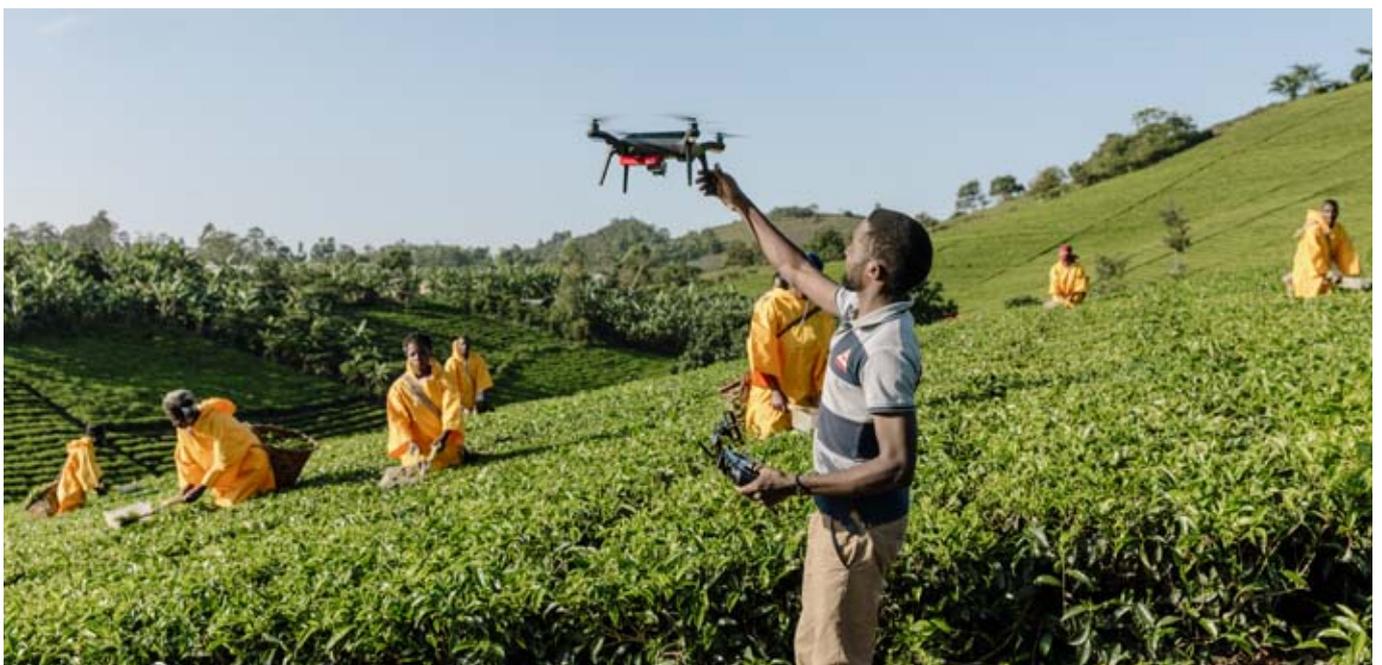
With the baseline that this report provides I believe we are well positioned to start scaling out solutions through partnerships, linking solutions providers, farmers' organisations, governments, development partners and others.

They say data is the new oil. While I prefer a more sustainable analogy, for Africa it is certainly the case that data might be the fuel that drives the transformation of smallholder farming and keeps the continent on track to meet its food and nutrition demands into this century and beyond. All the indicators point to a market that is ripe for investment now. And as long as we learn from lessons, do it right and manage risks and take into account data sovereignty, inclusivity, sustainability, we will all benefit.

This report is a valuable first step, we have seen an appetite to continually improve our understanding of the D4Ag landscape and chart the opportunity it offers for entrepreneurs, investors and governments. I hope our efforts will be valuable in guiding the opportunity and look forward to the collaborative push that I believe will bring D4Ag to life for the benefit of Africa's smallholder farmers and food and nutrition security across the continent.

Michael Hailu, Director

CTA





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The design, research and write-up of this report would not have been possible without the 120+ agribusiness leaders, experts and solution providers who shared their time, experience and knowledge. We are also grateful to the 175 D4Ag enterprises that took the time to participate in our survey, providing rich insights that strengthened the study.

The Technical Centre for Agricultural and Rural Cooperation, (CTA) commissioned **Dalberg Advisors** to lead the development of this study.

Dalberg is a strategy and policy advisory firm dedicated to global development. Dalberg was established in 2001 with the mission of bringing the best of private sector strategy to address global development challenges by combining rigorous analytical capabilities with deep knowledge and networks across emerging and frontier markets. Dalberg provides high-level strategic, policy and investment advice to the leadership of key institutions, corporations and governments, working collaboratively to address pressing global problems and generate positive social impact.

We would like to thank the members of the Advisory Council. The Advisory Council was led by **Michael Hailu** (CTA) and included the following individuals: **Vanessa Adams** (Alliance for Green Revolution in Africa), **Debisi Araba** (The International Centre for Tropical Agriculture), **Enock Chikava** and **Stewart Collis** (Bill and Melinda Gates Foundation), **Martin Fregene**, **Ed Mabaya** and **Kemi Afrun-Ogidan** (African Development Bank), **Anita Gardeva** and **Selina Kim** (IBM), **Clara Colina**, **Mikael Hook** (Rural and Agricultural Finance Learning Lab), **Su Kahumbu** (CEO Green

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From Dalberg, **Swetha Totapally** and **Michael Tsan** were the lead authors of the report, with research, analysis, and writing contributions from **Anders Engchild**, **Patrick Quigley**, **Zoe Savellos**, and **Pooja Singhi**. **Robin Miller** and **Naoko Koyama** offered advisory support. **Jesse Lichtenstein** and **Marty Schnapf** provided editing support and **Simon Mercer** from Mercer Design designed the report. The photographs from this report are drawn from CTA's internal photo bank.

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TECHNICAL CENTRE FOR AGRICULTURAL AND RURAL COOPERATION ACP-EU (CTA)

Established in 1983 and headquartered in Wageningen, Netherlands, CTA is a joint international institution of the African, Caribbean and Pacific (ACP) Group of States and the European Union (EU). CTA is primarily funded by the European Development Fund and receives additional funding through a diverse set of international partners.

CTA promotes food security, resilience and inclusive economic growth in Africa, the Caribbean and the Pacific through innovations in sustainable agriculture and actively engaging partner organisations for joint action and knowledge sharing. CTA focuses on digitalisation, youth entrepreneurship, and climate resilience as its priority intervention areas.

CTA's work on digitalisation, in particular, focuses on increasing the profitability and productivity of smallholder farmers by leveraging digital solutions and strengthening business innovations. It promotes precision agriculture solutions, weather information, soil sensors, drones for agriculture (where CTA is the key convener of the African UAV4Ag community) and other data-driven farming practices, as well as new services for farmers in the areas of finance and insurance. CTA's digitalisation work is closely linked to its other programmatic areas, including a focus on youth entrepreneurship in digital agriculture and the promotion of digitally-enabled, climate-smart agriculture solutions.

Building on earlier efforts and as part of the research for this report, CTA is now tracking ~400+ D4Ag organisations across Africa, including NGOs, social enterprises, government initiatives and purely commercial ventures that are (1) offering digitally-enabled agriculture services directly to smallholder farmers or (2) as business-to-business solution providers, extending digital agriculture products and services to other entities that interface with farmers.

CTA's current programmes target 900,000 farmers and expect to reach 2 million farmers by 2020. CTA's activities directly contribute toward achieving the UN's Sustainable Development Goals with a specific focus on SDG 2 (zero hunger, food and nutrition security and sustainable agriculture). CTA's efforts in D4Ag also map to the European Union's Digital for Development agenda as it supports programmes that advance digital infrastructure and regulatory reforms, digital literacy and skills, and digital entrepreneurship and employment.

CTA aims for this D4Ag report to be a foundational and regularly updated piece of research, which should serve as a valuable resource for the entire African D4Ag community, as well as an important tool in advancing the D4Ag knowledge agenda in the years to come.





EXECUTIVE SUMMARY



Fredrick Omondi, CTA

Context and methodology

Agricultural transformation remains one of Africa's most pressing priorities but has been difficult to achieve. The statistics are well-known: Africa, especially Sub-Saharan Africa, (SSA), needs to double (and perhaps even triple) current levels of agricultural productivity to meet continental demand and stave off food and nutrition insecurity.¹ The continent must achieve these targets while simultaneously adapting to climate change. Climate change is already impacting the agricultural sector with increasing climate volatility and the destructive effects of droughts, floods, new pests and diseases. With so much at stake, it is no surprise that most African countries have prioritised agricultural transformation as a key pillar of their national strategies. Yet, as the African Union's 2018 biennial review of the Malabo Declaration shows, fewer than half of countries (20 out of 47) are currently on track to meet their commitments by 2025.

Against this backdrop, digitalisation for agriculture (D4Ag) can be a game changer in supporting and accelerating agricultural transformation across the continent. D4Ag addresses a wide scope of factors and conditions affecting farms, farmers and the agri-food sector as a whole. The volume of data – and the supporting layer of new digital agricultural solutions – is growing exponentially at the same time that the quality of that data is rapidly evolving. For the first time, it is possible to precisely capture data from individual farms and fields, combine it in macro-level data sets, and utilise those sets in increasingly cost-effective ways. Why are digital solutions and agriculture data potentially so transformative? For farmers, they offer access to tailored information and insights that allow individuals to optimise their production, gain access to appropriate products and services, and explore new linkages with markets. D4Ag provides enterprises deeper understanding of their target segments, allowing them



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D4Ag can be a game changer in supporting and accelerating agricultural transformation across the continent. ”

to better tailor their interventions to the needs of smallholder farmers. Governments, likewise, can use improved understanding of farmer segments to improve macro-decision policy-making, as well as the design and implementation of their programmes. The result – if fully implemented at scale – would be a highly connected, intelligent, real-time agricultural ecosystem that is vastly more productive, efficient, and transparent than ever before. The growing quantity and quality of agricultural data and digital agricultural solutions *significantly reduce the costs* of service, inputs, and information delivery for farmers and other value chain intermediaries. This enables them to productively transform their traditional business models.

D4Ag has the potential not only to support agricultural transformation but to do so sustainably and inclusively.

An inclusive, digitally-enabled agricultural transformation could help achieve meaningful livelihood improvements for Africa’s 250 million smallholder farmers and pastoralists.² It could drive greater engagement in agriculture from women and young people and support employment opportunities along the agricultural value chain – and it could help build resilience to climate change. Still, D4Ag is not a replacement for physical infrastructure, human networks and human interaction. Digital tools can improve market efficiency, transparency, aggregation, and integration, but parallel investments in physical infrastructure (e.g., roads and electricity) are still needed to deliver inputs to farmers and to deliver farm products to market. Furthermore, human infrastructure (e.g., extensions, financial agents, agro-dealers, and agent networks), though it entails significant investment and ongoing

costs, is crucial to achieving real agricultural transformation and impact. While it may not be a cure-all, it is clear that D4Ag’s potential to contribute to Africa’s inclusive growth story is significant.

In this report, we set out to explore the gains D4Ag has made toward reaching its potential. Our ambition, therefore, is for this report to serve as a barometer for the current state of D4Ag in Africa.

Specifically, we (i) define D4Ag and establish a common language for the sector – the solutions, their use cases, and their potential; (ii) share how far the sector has advanced as of 2019; (iii) offer our perspective on where the sector will go in the next 3–5 years; and (iv) shed light on what it will take to further unlock the potential of the sector and explore the roles of different stakeholders.

Our findings are based on the triangulation of an extensive set of primary and secondary sources. These include (i) a survey that was sent to 430 D4Ag enterprises, with 175 responses received; (ii) a database that tracks 390 active D4Ag solutions in Sub-Saharan Africa and more than 70 defunct solutions with detailed information (where available) on each, including type of business model, reach, geographic presence, revenue and impact; (iii) interviews with more than 120 agribusiness leaders, technology experts, D4Ag solution providers, donors, investors, policymakers and academics; (iv) field visits and country case studies in Ethiopia, Nigeria, Senegal, Ghana and Rwanda, as well as lighter touch reviews of Kenya and the Sahel region; and (v) secondary research on D4Ag market assessments, business models, end-user needs and impact evidence.



CTA



Key findings

Sector reach and growth

- **A large number of players comprise this relatively young sector.** As of 2019, there are at least 390 distinct, active D4Ag solutions across the continent.³ As an indication of how quickly the sector is growing, nearly 60% of these were launched in the last three years, and approximately 20% were launched since 2018. The solutions span five major use cases: advisory services, market linkages, financial access, supply chain management, and macro agricultural intelligence. Additional use cases include D4Ag data intermediaries that focus on multiple downstream solutions. Furthermore, the amount of bundling is increasing – over 50% of active solutions combine more than one use case.
- **Reach is growing quickly.** D4Ag solutions have already registered over 33 million smallholder farmers and pastoralists across the continent (13% of all Sub-Saharan African smallholders and pastoralists and up to 45% of smallholder households, depending on assumptions used to calculate penetration). The sector has been growing at about 44% per annum over the last three years in terms of the number of farmers reached (i.e., registered for solutions). A small minority of companies (about 15, most of which focus on advisory services as their current primary focus) have begun to reach notable scale with 1 million plus registered farmers each.
- **The economics are improving, and a handful of players are beginning to develop viable businesses with attractive financial models.** We estimate that 70% of enterprises generate some revenue and 80% of those revenue-generating enterprises maintain several revenue streams. Of our survey participants, 26% were breaking even. While robust baseline data are not available for comparison, we believe that these results are significantly higher than even a few years ago. Importantly, a small but growing number of players are developing strong business models and demonstrating that it is possible to generate up to 90 of revenue per farmer annually, though the average is much lower (e.g., ~5 for advisory services, ~25 for market linkages, and 4 for digital financial service intermediaries and supply chain management solutions). While the cost structures for generating these revenues, of course, vary by solution type, there is evidence that some companies are able to achieve 30–40% gross margins. We do not expect all businesses to achieve this level of revenue or margin, but the data indicate that strong economics are achievable.
- **The addressable market is in the low billions, though only a fraction of it is being realised today.** We estimate that the total addressable market revenue is likely 2.3 billion (mid-range estimate, potentially as high as 5.3 billion in 2019), of which an estimated 127 million of sector revenues (107–145 million) are being realised today (~6% penetration of the total addressable market). The addressable market will continue to grow rapidly over the next decade with the growth of the smallholder population, improvements in connectivity and rising revenues per farmer as D4Ag business models become more established. These numbers shed light on business opportunities to significantly grow revenue, but they also suggest that D4Ag companies are still working out their business models and likely need to create more value for farmers and other customers across the value chain.
- **Registrations are concentrated.** While there are D4Ag solutions present in at least 43 out of 49 Sub-Saharan African countries, over half of the solutions are headquartered in East Africa and nearly two-thirds of registered farmers across all solutions are based in East Africa, with Kenya leading the way. Similarly, the



largest 20 solutions account for nearly 80% of farmer registrations. Moreover, while products are diversifying to address newer use cases like supply chain management, advisory services continue to dominate the market (two-thirds of total registrations).

■ **Investments remain small, and primarily fuelled by donors, while private investment is lagging.**

Donors are increasingly making D4Ag an important part of their portfolios. We estimate approximately \$75 million in annual donor funding flows for D4Ag. Private sector investment is even more limited – in 2018, there was investment of approximately \$47 million into African or Africa-focused D4Ag enterprises, including both start-ups and later stage enterprises. Investment into Africa-based D4Ag start-ups represented 3–6% of all Africa tech start-up investment in 2018. Because these figures are not well documented publicly, we likely have not fully captured all private investment. Still, these figures are quite small relative to the needs of commercial enterprises on the ground and represent a tiny fraction of the global investment flows to agricultural technology, which by some estimates reached nearly \$1.8 billion in 2017. Most of the funding has gone to specific enterprises; far fewer investments have been made in D4Ag infrastructure (e.g., farmer registries, soil testing infrastructure, weather stations).

D4Ag use and impact

■ **While D4Ag's reach figures are impressive given the relative nascence of the space, use remains low.** Our estimates suggest that 42% of registered farmers and pastoralists actually used the solutions they registered for with any frequency. While there is no standard definition for 'use' and the nature of farmer interaction with solutions differs depending on the solution type (e.g., digital financial product vs. digital advisory service), the number of highly active users is likely even



lower – i.e., likely in the 15–30% range, on average (based on self-reported data) across all use case areas.

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■ **Some promising impact metrics are emerging. Though early, limited and in some cases, mixed, the overall results suggest that D4Ag solutions could achieve transformative results.**

There are not many verified examples yet, but the few self-reported examples we do have suggest that some D4Ag enterprises are seeing highly positive direct and indirect impacts on smallholder farmers. The greatest amount of evidence points to a link between D4Ag and yield and income metrics. Here, a handful of players are leading the way with noteworthy results. Evidence for youth engagement and climate change is early but promising. The link to employment is largely hypothetical, though also promising. In terms of gender equity, however, the data suggest that, barring a handful of exceptions in which companies have made a focused effort to reach female farmers, the sector has made little progress.

■ **Yield and income:** A sample of approximately 50 impact data points, including both self-reported and





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independently validated impact studies, with average yield improvements across all data points of roughly 20% for advisory services, 70% for market linkages, and 40% for digital financial services, with corresponding income improvements typically ranging between 20% to 40%. Bundled models seem to have increased potential. Based on self-reported data, we see yield improvements in the range of 50–300% and income improvements on the order of 20–100%. While these numbers likely represent the most positive outliers, they are encouraging and demonstrate that some players have been able to achieve not just incremental but actually transformative results through D4Ag. Still, it is important to note that these figures represent the total impact on the yield and income of digitally enabled solutions, not just the incremental impact of digitalisation. Anecdotally, these figures are higher than those of purely analogue solutions and are generated at reduced cost and thus higher return on investment (ROI). Nonetheless, much more research needs to be done to quantify the advantages of digital over analogue solutions.

- **Youth:** The high share of youth engagement – more than 70% of registered users – is good news. At the same time, this figure likely also indicates an important age

divide that must be overcome in order to engage the significant proportion of farmers from older groups.

- **Climate resilience:** D4Ag has likely already helped reduce some effects of climate change by improving resource use (e.g., soil and water conservation due to advisory services), building resilience (e.g., via digitally-enabled agri-index insurance), and lowering postharvest losses for some farmers. However, the number of data points on climate impact is too limited to make compelling generalisations. Experts suggest that we have just begun to see the effects of D4Ag on climate resilience and that we should expect much more progress in this area in the coming years.
- **Employment:** While the sector currently lacks precise quantitative data or evidence on employment impacts, we believe that D4Ag will likely be a net job creator. In fact, it could even be a significant job creator, opening up hundreds of thousands of jobs in agricultural technology, D4Ag support, agricultural processing, and agricultural manufacturing jobs. As digital solutions justify upscaling, digitally-enabled human agent networks will play a critical role in linking farmers to inputs, finance and knowledge. It is also possible that D4Ag could help increase the share of smallholders in tight value chains and the quality of smallholder jobs.
- **Women:** The relative uptake among women is low – especially considering the disproportionate burden they bear on the farm. In sub-Saharan Africa, where 40–50% of smallholder farmers are women, only 25% are registered users of D4Ag solutions. Companies that explicitly target female farmers and make this an important measure of their success tend to do better. Overall, the data suggest that companies are not sufficiently prioritising gender as part of their product design, marketing and user engagement efforts.



Forward-looking trends

- **Several of today's barriers – notably, limited access to technology and connectivity – will begin to be overcome.** In particular, we expect that most farmers will have access to a mobile phone by 2030 (~50% penetration for unique mobile subscribers in rural Sub-Saharan Africa, but likely 80+%, based on current trends for share of smallholder households that have access to at least one mobile phone and reasonable connectivity). Many will also have access to smartphones – already more than 25% of smallholder farmers in countries like Kenya and Senegal report access to smartphones; these numbers are projected to grow quickly. The cost of data will continue to fall and growing, thriving mobile money ecosystems around the continent will serve as a strong foundation upon which to build platforms for D4Ag transactions.
- **D4Ag products and services will continue to improve.** Over one-third of our D4Ag sector survey respondents already use at least one form of advanced technology (e.g., drones, blockchain, machine learning, internet of things, or big data), and nearly 60% of respondents expect to integrate new technologies in the next three years. D4Ag solutions will leverage cutting-edge technologies fuelled by new sources of data and analytical capabilities – to reduce costs, increase their value proposition and enhance their precision, customisability and overall capabilities even as they become easier for farmers to access and use. We will move from a state in which we primarily have observational data to a state in which we can offer users real-time insights and predictive capabilities.
- **New entrants in the D4Ag space – including 'big tech' players like Microsoft, Google, IBM, Bosch and Alibaba, as well as 'big agri' incumbents like Bayer, Syngenta,**

Yara, John Deere and UPL – will change the sector's scale and scope.

Many of these players have already begun to enter the market via exploratory acquisitions, innovative partnerships, and new product development. Others are more quietly holding exploratory conversations and initiating small-scale pilot programmes. Their presence will bring increased financial, human and technological resources to the sector, and may be accompanied by major investment in important underlying infrastructure. Such improvements could significantly improve sector growth. Still, their entry does not replace the need for strong local talent. The capabilities of big tech should complement organisations on the ground that are well positioned to design products that can serve the needs of farmers in their region and business models that will work given local conditions. The best models will pair localised knowledge with big tech capabilities.

■ **We will enter a platform-led era.**

Platforms that bring together several use cases, diverse value chains, and the best capabilities of multiple players are the most likely to succeed. Such D4Ag 'super platforms' are already emerging, with a range of private, donor-led, government-led, and public-private partnership models. While we cannot predict who will emerge as the leader(s), and there are likely to be multiple different successful models depending on the country, we expect that these platform players, in partnership with some of today's leading specialist D4Ag solution providers, will bring about in a step change in the D4Ag sector's reach and impact.

- **The reach of digital solutions will continue to grow and may include as much as 80% of the smallholder farmer population.** At 44% per annum, the sector's growth rate is currently very high; access to technology is likely the main limiting factor for the spread of D4Ag solutions. Given that Africa will



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achieve near universal phone access in the coming years, current growth trends suggest that 100 million smallholder farmers could be registered for D4Ag services within three years and as many as 200 million smallholders will sign on by 2030. This estimate may be high, however, and a more conservative scenario of ~60 million registered farmers by 2022 is probably more credible, as it will become progressively harder to reach additional smallholder farmers from remote and vulnerable populations living in less stable and poorly connected environments. Nevertheless, the core implication of these numbers is that reaching farmers will not be the main bottleneck for D4Ag solutions; rather, the next phase will require a tight focus on increasing use among and impact for smallholder farmers.

Challenges

- **The sophistication of D4Ag solutions has begun to outpace the readiness of entrepreneurs, users and government actors to embrace and leverage them.** As discussed above, the underlying technologies and capabilities of D4Ag solutions are advancing quickly. We now have an opportunity to shift focus from technologies and solutions to the underlying enabling environment. For example, insufficient human capital

development remains a major barrier: 49% of D4Ag enterprises that responded to the survey reported that this was a key growth challenge. Similarly, 28% of survey respondents cited consumer-level barriers (e.g., digital literacy) as one of the top three challenges to adoption and use.

- **Most companies are still working to develop a viable business model.** While some companies have started to reach scale and earn profits, the vast majority of businesses still rely on donor funding and continue to experiment with business models that are attractive to funders and customers. In recent years, the sectors have learned a lot about what models *do not work*; we are still in the earliest stages of understanding what models *work*. For example, experience from several businesses suggests that farmers are unlikely to pay for D4Ag services (especially advisory services) and that data are challenging to monetise. Drawing on these experiences, companies are beginning to experiment with new approaches, e.g., taking a cut of the value created for customer segments. This may have strong promise, but companies will have to continue to deliver greater value to farmers – and thereby translate customer reach to customer use – in order to achieve improved business economics. In the meantime, many companies whose full attention is fixed on developing a viable business model deprioritise or miss important issues like impact and data stewardship, viewing them as secondary in importance or even running counter to their objective of turning a profit.
- **The lack of D4Ag infrastructure – farmer registries, digital agronomy data, soil mapping, pest and disease surveillance, and weather data infrastructure – in most contexts reduces the effectiveness of D4Ag solutions.** Such investments are important building blocks for individual enterprises

Fredrick Omondi, CTA



and for the D4Ag ecosystem more broadly because they drastically reduce transaction costs, drive efficiency and increase the effectiveness of solutions. Yet, investment in such public goods and enablers is quite limited and just beginning to emerge at national and local levels. The case for making such investments is not always straightforward; based on some existing approaches, they could produce results at the expense of good data stewardship (e.g., customer privacy, appropriate consent, security, etc.). Good data stewardship and strong middleware can coexist, but we have not yet seen a strong focus on this in the sector.

- **High degrees of country-level and regional variation in investment expose uneven D4Ag growth across the continent.** While market-driven growth in D4Ag solutions in countries like Kenya, Ghana, Nigeria, Senegal, Rwanda and Côte d'Ivoire serves as a strong inspiration for others, the level of variation across countries highlights some important challenges. For example, it indicates that donors, investors and, to a somewhat lesser extent, enterprises are still risk-averse and likely prioritise the easiest-to-reach markets (e.g., markets where other providers already exist and where the ecosystem is stronger). This also occurs within individual countries, where companies largely target the easiest to reach customers. Such uneven growth could further worsen the digital divide between different communities. The experience of other base-of-pyramid markets, such as that for energy access, suggests that the transfer of technological innovation from more advanced geographies to lagging ones is not an automatic process and can, in many cases, be quite slow in the absence of well-targeted investments and policies.

Recommendations

The focus over the last 15 years – the 'ICT4Ag' age – has been on developing



and testing the potential of digital solutions in agriculture. In the next decade – the 'D4Ag' age – the aim will be to translate this potential into reality – and do so equitably and sustainably. As part of this D4Ag journey, the sector made quick strides toward reaching large numbers of farmers in a challenging environment with an impressive set of products, services and innovative business models.

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In the next phase of D4Ag, we have an opportunity to improve use and drive greater inclusivity and impact. But we must do so while actively managing the risks of digital tools. This will require sector actors to make several major investments in the improvement of business models and especially the D4Ag ecosystem. As we work to mainstream D4Ag, we recommend that donors, governments and investors:

1 **Develop human capital at every level of the D4Ag ecosystem.**

Developing human capacity will be critical to building D4Ag readiness across the ecosystem, from farmers to government officials. The necessary growth in human capital includes increased awareness of D4Ag, improved digital





Georgina Smith, CLAT

literacy and greater digital skill building among smallholder farmers and other actors across the agricultural value chain. Such growth will require deeper investment across Africa in those sectors of the developer ecosystem most capable of boosting human capital, i.e., start-up ecosystems, incubators, accelerators, etc. Efforts must also be made to increase the capacity of government workers – particularly in ministries of agriculture, livestock, forestry, fisheries and ICT – to understand how to use and deploy D4Ag solutions in various public initiatives.

2 Drive greater business model sustainability.

Consistent with other sectors and geographies, Africa needs to prove that D4Ag deployments can be sustainable in order to drive greater investment. Key to driving greater business model sustainability will be improving value for farmers, identifying and promoting successful business models and mobilising funding to support a more diverse set of companies. A focus on improved product design, support for consortium/platform-based initiatives, continued push toward B2B (rather

than B2C) offerings and deeper research on D4Ag business models will go a long way in supporting this objective.

3 Create greater impact by making D4Ag solutions more inclusive of women, other marginalised groups, and smallholders in geographies with relatively less D4Ag investment.

Today, D4Ag solutions primarily reach the low-hanging fruit – farmers in tight value chains – while many enterprises fail to equitably reach women and other marginalised segments of the community. To achieve equitable growth, D4Ag needs to be more inclusive. We recommend that governments and donors offer greater support for enterprises in geographies that have historically attracted less investment, and that they incentivise D4Ag enterprises to target marginalised population segments, especially women, who are systematically left behind. Donors, in particular, can play a key role in catalysing greater targeting of marginalised communities.



4 Invest in the missing middleware infrastructure. Successful D4Ag solutions require access to a wide range of data (from remote sensing data to farmer-specific data) in order to deliver high-quality services to farmers.

These data need to be accurate, reliable and, in many cases, available in real time. We recommend that governments and donors – potentially in partnership with private actors – lead the development of important agriculture data infrastructure, including digital agronomy data (e.g., land, water and crop maps), soil testing infrastructure and data maps, weather/climate tracking infrastructure, digital pest/disease surveillance systems, farmer data registries and agriculture transaction registries and commodity exchanges. It is particularly important to get the middleware right – from design to policy to implementation – so that everything built on top of it works and ultimately helps, rather than hurts, farmers. It is not enough to make these investments in a vacuum. Coordination between governments, donors, investors, farmers and other interested parties will likely reduce duplication of efforts and result in higher-quality, efficient infrastructure that enterprises can rely on across geographies.

5 Invest in good data stewardship and design for the risks and limitations of digital systems.

Specifically, we recommend that governments – with support and input from donors – design and implement appropriate policies and regulations to promote good data stewardship. Some of these will be specific to agriculture (e.g., policies around farmer registration) while others will take the form of good data governance writ large (e.g., consumer privacy, informed consent, etc.). Such policies are critically missing from the conversation today (though they are beginning to emerge) and will become even more important as the sector begins to invest in a middleware layer and

big technology actors expand their footprint. We have an opportunity to manage these risks before they become realities. To do so, governments must design approaches that appropriately balance the need for good data stewardship with the desire not to overregulate and stifle D4Ag innovation.

6 Invest in the D4Ag knowledge agenda.

We still have a long way to go in learning what works and what does not. As the sector matures, there is a good opportunity to develop a set of best practices and a stronger community of practice with which to share lessons learned. Development partners will likely make these investments, with important contributions from governments and investors alike. We recommend knowledge investments in three major areas: how to design offerings that meet the needs of farmers, in particular women and other under-served communities; research to gather better market and business model intelligence to drive success in D4Ag; and research to gather more robust evidence on the impact created by different use cases and business models.

7 Create an alliance of key D4Ag stakeholders to promote greater investment, knowledge sharing and partnership building.

Investment in D4Ag has been isolated, scattered and piecemeal. Innovations, deployments, investments, assessments and reports are being unnecessarily duplicated. There is no ‘go-to-place’ or knowledge clearinghouse for D4Ag across the continent. With the results of this report as a baseline, there is an opportunity for a new alliance for digitalisation in African agriculture to lead knowledge sharing, collaboration, and growth in the sector. This alliance should be built as a partnership between governments, donors, international bodies, farmer organisations and the private sector dedicated to advancing inclusive, sustainable D4Ag across Africa and beyond.



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WHY AFRICA NEEDS A DIGITALLY-ENABLED AGRICULTURAL TRANSFORMATION



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Africa needs an inclusive and environmentally sustainable agricultural transformation to build greater food security, improve nutrition, and expand economic opportunity. D4Ag has significant potential to act as a driving force behind Africa's agricultural transformation in the coming decades.

Agricultural transformation

A state in which agriculture is a vibrant, modern and sustainable business that creates value for farmers, entrepreneurs, youth and women, and produces affordable, nutritious and healthy food for all. (CTA)

Africa must massively and sustainably increase its agricultural output – to more than double current levels of production – over the next three decades to meet growing demand and achieve food and nutrition security.⁴

Sub-Saharan Africa, in particular, already faces the greatest food security risk of any region. By 2050, its population is expected to increase 2.5-fold while demand for staple cereals will approximately triple over this same time period.⁵ This growth in demand will substantially outpace the historical rate of agricultural productivity and yield increases in the region. Although the number of

malnourished people has declined since 2000, over a fifth of the population in Sub-Saharan Africa experiences chronic undernourishment, and around 35% of children under five were stunted in 2016.⁶ Malnutrition causes stunting, wasting, obesity, and anaemia in reproductive-aged women, among many other health and non-health consequences.⁷ Agricultural transformation will help farmers increase productivity, yield, and income, enabling them to consume more nutritious food (that they have grown or purchased). For society at large, agricultural transformation will likely result in lower prices while improved market linkages will result in greater access to nutritious food.⁸



“

Climate change is making farmers even more vulnerable than they already were. ”

Africa must realise these gains while also adapting to climate change and mitigating further damage to the environment. Farmers have always been susceptible to climate variability and extreme weather events. Climate change is making farmers even more vulnerable. They are already experiencing smaller and more variable harvests, new pests and diseases, and more severe droughts and floods; all indications are that these conditions will all worsen substantially in the coming decades as temperatures increase and extreme climate events become far more common.⁹ To achieve its objectives, agricultural transformation must improve farmer resilience to these climate effects. Agricultural production increases must also be achieved in ways that limit further adverse environmental effects of agricultural intensification and cropland expansion – most notably, the overuse of natural resources like water, soil degradation and biodiversity loss.

Agricultural transformation has the potential to drive African economic transformation by boosting economic growth through more formal and efficient smallholder farmer value chains, reducing food imports and increasing agricultural exports (both within and outside of Africa), decreasing post-harvest losses and improving efficiency in activities such as agricultural processing, storage, transport and logistics. Dramatically increased production and resulting increases in economic growth are possible. McKinsey & Company has estimated that Sub-Saharan Africa has the untapped agricultural potential to double or triple the amount of cereal and grain it produces today;¹⁰ the potential for productivity gains is equally large for many other key staple (e.g., cassava,

sweet potato, banana) and horticultural crops in Africa. The economic upside of such improved agricultural productivity would be tremendous given the very large share that agricultural activities contribute to regional GDPs. The Brookings Institution, for instance, has estimated that a half-ton increase in staple yields alone could generate a 13–20% higher GDP per capita in many developing countries.¹¹

Agricultural transformation can also serve as an engine for social inclusion.

There is an opportunity to better engage and empower Africa’s women, who constitute at 40–50% of the continent’s smallholder producers.¹² Africa also faces a high level of youth unemployment with the projected entry of over 100 million young Africans into the job market by 2030 and the demographic reality that, for years to come, more than half of Africa’s youth will continue to live in rural areas.¹³ Agricultural sector transformation could have a major role in generating higher-quality jobs and entrepreneurship opportunities for Africa’s youth. Such youth engagement in agricultural employment is increasingly important given that the average age for an African farmer is 60 years old.¹⁴

For decades, many African governments have recognised the importance of agricultural transformation and the opportunities it presents, yet several complex and stubborn challenges have slowed progress. Given its central importance to their near-term future, a few dozen African countries have already made agricultural transformation a key pillar of their national strategies and growth plans.

Food and nutrition security

Condition in which all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. (United Nations)

Smallholder farmer

Individuals who produce crops or livestock on two or fewer hectares of land (World Bank). Technically speaking this term only includes farmers and agro-pastoralists who are tied to specific pieces of farmland, but this report uses the term more loosely to refer to small farmers, agro-pastoralists, and nomadic pastoralists.

Agricultural value chain

Set of actors and activities that bring a basic agricultural product from production in the field to final consumption, adding value to the product at each stage. (FAO)

Youth

People between the ages of 15 and 35 years. (African Union)



However, as of 2018, only 20 out of the 48 countries that completed the survey (39%) are on track to meet their Malabo Declaration commitments by 2025, according to the Africa Agriculture Transformation Scorecard.¹⁵ There are many reasons why agricultural transformation has not been easy to achieve – not least, the large investments required. An estimated $\text{€}40$ billion annually is needed to harness the power of agriculture to transform Africa, whereas only approximately $\text{€}6.25$ billion is invested annually today.¹⁶ Beyond resource constraints, other major and often interrelated challenges include poor national institutions and weak enabling environments, underdeveloped transportation and energy infrastructure, insufficient digital connectivity in rural areas, low availability and uptake of high-quality agricultural inputs and technologies (such as seeds and fertiliser), insufficient water resources, soil degradation, limited financial inclusion for farmers, and the need for improved human capacity and access to agricultural knowledge.¹⁷

Digitalisation can help accelerate agricultural transformation in Africa

The strategic use of digital technologies, data, and innovative digitally-enabled business models can (and have already begun to) accelerate sustainable agricultural transformation in Africa.

Digitalisation for agriculture (D4Ag) is the use of digital technologies, data and business model innovations to transform practices across the agricultural value chain and address bottlenecks in, *inter alia*, agricultural productivity, postharvest handling, market access, finance and supply chain management so as to achieve greater incomes for smallholder farmers, improve agriculture value chain economics for agribusinesses both large and small, expand the economic inclusion of youth and women, improve overall food and nutrition security and build climate resilience – all while mitigating the potential negative environmental effects of agricultural

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intensification. Not only can the integration of D4Ag tools help address these important bottlenecks to agricultural transformation, but we also believe it can do so faster and more cheaply than status quo, non-digital approaches because improved cost efficiency, accelerated innovation, and rapid product and service dissemination are the hallmarks of digitalisation.

The idea that digital solutions can be used in agriculture is certainly not new. For the past 15+ years, innovators in Africa have been experimenting with various information and communication technology for agriculture (ICT4Ag) solutions. These efforts – which have largely been one-offs – have helped farmers, agribusinesses and governments become more comfortable with using technology in the context of agriculture. We refer to these initial efforts as characterising the **ICT4Ag age**. Now, fuelled in part by the foundations laid by ICT4Ag, we have entered the **digitalisation for agriculture (D4Ag) age**.

This is more than a semantic shift – this report argues that we are on the verge of dramatically expanded possibilities for the impact of digital solutions on Africa's agriculture. The era of D4Ag is distinguished from what preceded it in at least four ways.

First, there is a much **broader range of digital technologies** that innovators can draw on beyond basic information collection and communication tools (e.g., satellites, drones, portable diagnostic technologies and sensors linked to the internet of things).

Second, there is a move from using digital technologies for information dissemination to the **true digitalisation of the agriculture ecosystem**, including digitalising how farmers and other agriculture value chain participants pay for goods and services (or access finance), how they connect and transact as buyers and sellers, how they manage operations and

logistics, and how they make decisions about the future.

Third, business models are rapidly diversifying as **many more commercial actors and investors enter** the space. Despite many challenges, we argue that this augurs well for the rise of more commercially viable and scalable digital agriculture platforms.

Finally, D4Ag is distinguished by its **focus on data and data systems as the key input and output – the lifeblood – of innovative agricultural business models**, which we believe will help drive systemic change rather than just one-off, project-level improvements.

D4Ag can help a range of important actors in the agricultural ecosystem. We describe the potential impacts of D4Ag on these stakeholders in Figure 1. In some cases (though not all), we already see some of this potential translating into reality. The level of progress made, relative to the impact potential of D4Ag, is a major area of exploration in a later section of this report.

Beyond supporting individual actors, D4Ag has the ability to promote intra-regional trade. Aside from positive impacts on smallholders and other individual agriculture value chain actors, D4Ag should ultimately make an impact on important macro-economic conditions and priorities. As an illustration of this potential, one of the Malabo Declaration's priorities is to triple intra-regional trade in agricultural products by 2025. D4Ag can help the production of surplus products, improve the connectivity of products to various markets and strengthen the efficiency, quality and transparency of supply chains, ultimately making cross-border trade across markets more attractive and less risky than it is today. D4Ag could similarly encourage greater trade between African countries and nations outside of Africa.



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Figure 1 **Potential D4Ag impacts on African smallholder agriculture ecosystem**

Category	Actor	Potential D4Ag impacts (non-exhaustive)
Smallholder farmers (SHFs)	All smallholder farmers and pastoralists	<ul style="list-style-type: none"> • Greater productivity via the dissemination of agricultural advice and real-time information, better financial access, and improved linkages to quality agricultural input and reliable off-take markets • More sustainable farming practices that help maintain productivity over the long term and reduce costs (e.g., water and input use) in the near term • Increased chances to obtain formal land titles thanks to digital mapping of farm boundaries • Increased farmer incomes as farmers produce greater quantities, face lower crop losses and access fairer input and off-take prices • Improved nutritional outcomes of SHFs as they grow, purchase and consume more nutritious food • Inclusion of SHFs in more commercial value chains due to reduced transaction cost and risks
	Climate-vulnerable SHFs	<ul style="list-style-type: none"> • Better climate resilience through improved weather forecasts, advice on climate-smart agricultural practices, improved access to weather-adaptation inputs and weather index-based insurance
	Women SHFs	<ul style="list-style-type: none"> • Better understanding of women farmers' unique needs and tailored design of solutions due to the capture of large volumes of high-quality gender-disaggregated data • Greater access of women farmers to relevant advice, finance, agri-inputs
	Rural youth	<ul style="list-style-type: none"> • Greater youth interest in agriculture as digitalisation increases sector attractiveness for the young • More jobs and improvement in the quality of existing jobs in agriculture as digitalisation generates new opportunities in farming and farming-adjacent sectors (e.g., farm agents, processing jobs) • New high tech employment opportunities (e.g., D4Ag software development, data analytics)
Business	Input providers (e.g., agro-dealers, input producers)	<ul style="list-style-type: none"> • Expanded farmer demand for input products (increasing revenue) • Improved cost-efficiency of input distribution due to digitally linked value chains and digital tools for input supply chain management and logistics optimisation • Greater input value chain transparency, traceability and thus input quality (e.g., widespread use of quality assurance and anti-counterfeiting tools to protect brand owners and farmers)
	Off-takers (e.g., buyers, processors, traders)	<ul style="list-style-type: none"> • Increased volume of high-quality produce from SHFs due to better practices and input use • Enhanced market efficiency and interconnectedness with more integrated and transparent value chains and less wasteful production and post-harvest stages all contributing to growth and profits • Improved quality and safety of food products coming out of smallholder value chains due to digital traceability and tracking tools and digitalised supply chain logistics
	Financial service providers (FSPs) (e.g., banks, MFIs, insurers, payments players)	<ul style="list-style-type: none"> • Lower costs to identify, acquire, and service smallholder farmers due to digital channels and tools that directly improve FSP profitability and expand potential universe of economically viable clients • Improved ability to assess, monitor and manage financial product risks via innovative analytics of digitalised farmer, field (e.g., soil), weather and remote sensing data • Lower risks of serving farmers due to digitally-enabled delivery of better advice and market linkages
Government	Agriculture ministries, national extension agencies	<ul style="list-style-type: none"> • Support for national macro-objectives such as sustainable agricultural transformation, food and nutrition security, job creation and improved climate resilience • Improved cost-efficiency and more targeted impact of government investment into agriculture (e.g., less leakage from agri subsidies, more accountable and cost-efficient agronomy and extension) • Much better macro intelligence on agriculture sector trends, opportunities, and risks at national and sub-national levels allowing for improved planning, resource-allocation and crisis management
Agronomy R&D sector	CGIAR, National Agriculture Research Centres (NARS), private agronomy actors	<ul style="list-style-type: none"> • Improved linkages between upstream agronomy R&D and on-the-ground agricultural product development and agronomic advice due to richer and more intensive digital data feedback loops • Lower costs of collecting field data (e.g., digital tools for data collection and field trial management) • Improved insights for agronomists into farmers' wants and needs due to large-scale farmer data • Methodological innovation (geospatial agronomy) due to the availability of much greater volumes of remote sensing (satellite/drone) and ground truth (e.g., digitalised field trials and yield measurement)
African population at large		<ul style="list-style-type: none"> • Improved food security due to the much wider availability of lower-cost and more nutritious food • Improved food quality and safety and faster resolution of food safety issues (i.e., due to traceability) • New jobs and entrepreneurship opportunities outside of rural areas but linked to agriculture sector (e.g., D4Ag software development, analytics, derivative financial services and trading jobs)

We are already starting to see important signs of progress, as well as notable areas for further improvement. This report serves, therefore, as a barometer of the progress to date and aims to accelerate digitally-enabled agricultural transformation by establishing a rich, repeatable baseline for sector data and highlighting key emerging opportunities. At the same time, the report also acknowledges substantial challenges to progress and offers recommendations for how these challenges could be addressed. In the sections that follow, we specifically:

- Describe the D4Ag ecosystem, establish a common language for D4Ag use cases categories and major solution sub-types, and explore each use case with on-the-ground examples (Chapter 2).
- Share how much progress has been made in the D4Ag sector as of early 2019 (Chapter 3).
- Offer perspectives on forward-looking trends that will define the evolution of the sector (Chapter 4).
- Shed light on what it will take to unlock the full potential of the sector (Chapter 5).
- Offer perspectives on the role governments, donors, and private actors will need to play to unlock this potential (Chapter 6).

Throughout the report, we focus on the reach of D4Ag, its use, and how it impacts

smallholder farmers. Given the size of this segment, its vulnerability, and its importance to agriculture in Sub-Saharan Africa, any attempt at inclusive agricultural transformation must prioritise solutions that deliver value to African smallholder and pastoralist households and other smallholder value chain intermediaries.

Of course, digital solutions cannot do it alone. Major challenges and risks are associated with digitally-powered agricultural transformation. Digitally-

enabled transformation cannot sidestep the need for fundamental infrastructure investments (e.g., roads, energy, irrigation) and important improvements in the underlying agriculture policy environment. Moreover, digitalisation brings real risks. D4Ag will likely accelerate the decline in the number of agriculture sector jobs in Africa as consolidation increases. While some farmers may benefit from digital technology, others could easily fall behind new types of ‘digital divides’. Women, for example, could be more disenfranchised. Finally, digitalisation creates its own, often poorly understood, risks to agriculture sector data privacy and information security. Given their information constraints and limited economic resources, smallholders are particularly vulnerable to such risks. We explore these challenges and consider how to overcome them in Chapters 5 and 6.

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THE D4AG ECOSYSTEM



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The D4Ag ecosystem in Sub-Saharan Africa presents a complex and fast evolving landscape. At the core of the ecosystem – and this report – are five use cases for D4Ag solutions, which are supported by D4Ag infrastructure (e.g., ag data systems), digital enablers like payments, and a general enabling environment layer.

D4Ag Solution Landscape – Defining Key Terms

The definitions of D4Ag ‘solutions’ and D4Ag ‘actors’ and ‘enterprises’ in this report are intentionally broad to accommodate the complexity and dynamism of the sector.¹⁸

The digital solutions covered in this report span the full smallholder agriculture value chain, including pre-production planning; agricultural input production (e.g., seed production management), marketing, distribution and ongoing monitoring (e.g., for farm machinery and irrigation); support for production-stage activities and decisions for farming and

livestock management; support for post-harvest activities such as processing, storage and transport; linkages to buyers and off-take markets; and cross-cutting value chain activities such as input and produce quality assurance and the delivery of financial services.

These solutions encompass a wide variety of digital technologies and tools, including everything from agronomic advice and information delivered via short message services (SMS) and interactive voice response (IVR) to smartphone applications that link farmers to multimedia advisory content, farm inputs, and buyers. There are business solutions that rely on sophisticated



software and data analytics platforms to help agribusinesses to manage their smallholder supply chains; financial technology solutions that digitise payments or utilise satellite and weather data to analyse the creditworthiness of farmers and deploy new types of agricultural insurance; and agriculture dashboards and decision tools for policymakers.

The report defines the ecosystem of D4Ag actors broadly, as well, to include NGOs, social enterprises, commercial ventures, government agencies and others that offer digitally-enabled agriculture services. They may do so directly to smallholder farmers or as business-to-business solutions for entities (e.g., smallholder-focused extension agents, agribusinesses, financial institutions and policymakers) that interface with smallholder farmers or make decisions about smallholder value chains. This D4Ag definition is not limited to purely digital enterprises. Rather, many of these companies meld digital products and digital delivery channels with human agents who support the delivery of advisory, market facilitation, logistical and financial services.

This report categorises D4Ag solutions into five primary use cases: (i) advisory and information services; (ii) market

linkages; (iii) supply chain management; (iv) financial access and (v) macro agricultural intelligence. Each of these five use case categories includes many underlying sub-types of solutions. There is also arguably an additional emerging sixth use case category of **D4Ag ‘super platforms’** – end-to-end solutions that cut across all other use case categories – which we believe are a path to the future of D4Ag and are thus covered separately.

Figure 2 provides detailed definitions of these use case along with some illustrations of the underlying types of solutions for each. Further detail on each use case follows later in this chapter.

While donors, investors, implementers and market intelligence actors continue to group D4Ag use cases or categorise individual solutions in a wide variety of ways,¹⁹ the vast majority of D4Ag enterprises still primarily focus on only one of the five discrete use case areas proposed in this report. Given the early stage of many D4Ag business models and the rapid pace of sector innovation, any terminology scheme for the D4Ag landscape is necessarily provisional. Furthermore, as we will cover in much greater depth later in

D4Ag ‘solution’ and ‘enterprise’ definitions

D4Ag ‘solutions’



Products and services that utilise digital tools, digital channels, or digitally-enabled data analytics (e.g., machine learning/ AI) to deliver information, advice, farming input linkages, market access, logistics support, financial services, and decision-making tools directly to smallholder farmers or to other intermediaries of smallholder value chains, including extension agents, agro-dealers, agribusinesses, financial service providers and policymakers.

D4Ag ‘actors’ or ‘enterprises’



Organisations, whether commercial or non-commercial, that develop D4Ag solutions or that deliver D4Ag solutions to farmers and other smallholder value chain actors.

While many D4Ag enterprises have only one D4Ag solution on the market, others hold multiple D4Ag solutions with different features and customer bases. Some D4Ag enterprises, such as regional MNOs, deploy multiple solutions under different brands in different countries.

Giacomo Rambaldi, CTA



Figure 2 D4Ag use case definitions and example solutions

D4Ag use cases	Definition and link to smallholder farming ecosystem	Examples of solutions
Advisory & information services 	Digitally delivered information on topics such as agronomic best practices, pests and diseases, weather and market prices, as well as more sophisticated digital advisory services and farm management software tailored to the specific farmer, farm or field that enable smallholder farmers to make decisions that maximise output from their land, improve the quality of agricultural production and maximise farm revenues and profits via lower costs of production, improved ability to identify markets and/or better price realisation.	<ul style="list-style-type: none"> • Agronomic/livestock management good practices • Market information systems and services (i.e., agriculture input and crop/livestock price intelligence) • Early warning tools for weather/climate advisory or pest/disease control • Customised (precision) advisory services at the level of farmer, farm or specific field • Participatory platforms (e.g., peer-to-peer smallholder communities, curated farmer videos) • Livestock and farm management software
Market linkages 	Digitally-enabled solutions that link smallholder farmers to high-quality farm inputs (e.g., seeds, fertilisers, herbicides/pesticides), production and post-harvest machinery and mechanisation services (e.g., irrigation, tractors, cold storage), or off-take markets, including agro-dealers, wholesalers, retailers, or even to end-consumers. Digital market linkage solutions allow smallholder farmers to lower their costs of production via access to lower-cost and/or higher-quality inputs, reduce the costs and risks of finding and transacting with buyers and ultimately increase their yields and incomes.	<ul style="list-style-type: none"> • Linkage to agri-inputs (e.g., digitally-enabled input distribution, online input marketplaces) • Mechanisation linkage platforms (e.g., shared economy for mechanisation, pay-as-you-go irrigation) • Linkage to market access (e.g., digitally enabled linkages to wholesale buyers) • End-to-end integrated market linkage models (e.g., digital linkage to both inputs and markets) • Ag buyer-seller digital marketplaces/exchanges
Supply chain management 	Digital supply chain management solutions are business-to-business services that help agribusinesses, cooperatives, nucleus farms, input agro-dealers and other smallholder farmer value chain intermediaries to manage their smallholder relationships in ways that lower costs through greater efficiency, improve value chain quality through better traceability and accountability and ultimately increase smallholder farmer yields and incomes by making it easier for more commercial players to formally engage with large numbers of smallholder farmers.	<ul style="list-style-type: none"> • Traceability solutions (e.g., digital sustainability and organic product certification tracking) • Enterprise Resource Planning (ERP) platforms for smallholder farmer cooperatives, nucleus farms, agribusiness out-grower schemes • Digital quality assurance solutions for farm inputs and produce • Logistics management solutions for post-harvest cold chains, storage and transport
Financial access 	Digital financial services (DFS) relevant for smallholder farmers, such as digital payments, savings, smallholder credit, and agricultural insurance, which increase financial access and equip smallholder farmers to improve yields and incomes and invest in the longer-term growth of their farms (e.g., via better inputs, mechanisation and expansion to new crops). Also includes business-to-business digitalisation and data analytics services for financial institutions that enable such institutions to serve smallholder farmers at substantially lower cost and risk.	<ul style="list-style-type: none"> • Smallholder farmer payment solutions (e.g., agribiz to farmer, government to farmer, farmer to input supplier) • Digital agri-wallets and commitment savings systems • Smallholder credit (e.g., digital credit assessment/delivery/collection platforms and products) • Smallholder insurance (e.g., digitally-enabled index weather, precipitation, pest insurance) • Crowdfunding platforms for smallholder farming • Business-to-business fintech data analytics intermediaries (e.g., digital credit profiles)
Macro agricultural intelligence 	Data analytics solutions and digital decision support tools that integrate a variety of data sources on smallholder farmers, farms and markets and convert this information into useful country- and value-chain-level insights and decision tools for government policymakers, extension agencies, agronomists, agribusinesses and investors.	<ul style="list-style-type: none"> • Government agriculture sector tracking dashboards • Agriculture extension system management tools • Agribusiness and agriculture investor national and regional intelligence systems • Agronomy/R&D agenda setting digital tools • Weather and climate observatories for agriculture



this report, D4Ag enterprises are increasingly diversifying their business models and bundling services in ways that often blur the boundaries between these use case areas and focus on several use cases at once.

Despite these caveats, we believe that the use case categorisation scheme proposed in this report is a useful tool for characterising the current state of the sector and for ongoing tracking of how the D4Ag landscape evolves in terms of the number of solutions, the reach of these solutions into the smallholder farmer population, investment trends, technology and business model innovations and impact evidence.

Contextualising D4Ag Solutions in the Broader D4Ag Ecosystem

While the five D4Ag use case categories and related solutions in Sub-Saharan Africa are the primary focus of this report, these use cases are only the top-most ‘application’ layer of a much broader digital agriculture ecosystem.

To achieve positive impact on smallholder farmers at significant scale, D4Ag solutions must be supported by strong underlying **D4Ag infrastructure** as well as by an **overall enabling environment** conducive to a well-functioning digital agriculture ecosystem. Additionally, to support and accelerate overall agricultural transformation and to ensure that digital solutions produce positive impacts for individual smallholder farmers, the D4Ag ecosystem must be supported by **parallel developments in the broader agriculture sector**. These developments include the advent of well-designed agriculture policies, increased investment in the formalisation of agricultural input and off-take markets, advances in local and regional agronomy research systems and agricultural trade policies.

The D4Ag ecosystem map in Figure 3 outlines the relationships between the overall



enabling environment, D4Ag infrastructure, and individual D4Ag solution use cases and illustrates how D4Ag can simultaneously support macro impacts like agricultural transformation and smallholder-level impact objectives.

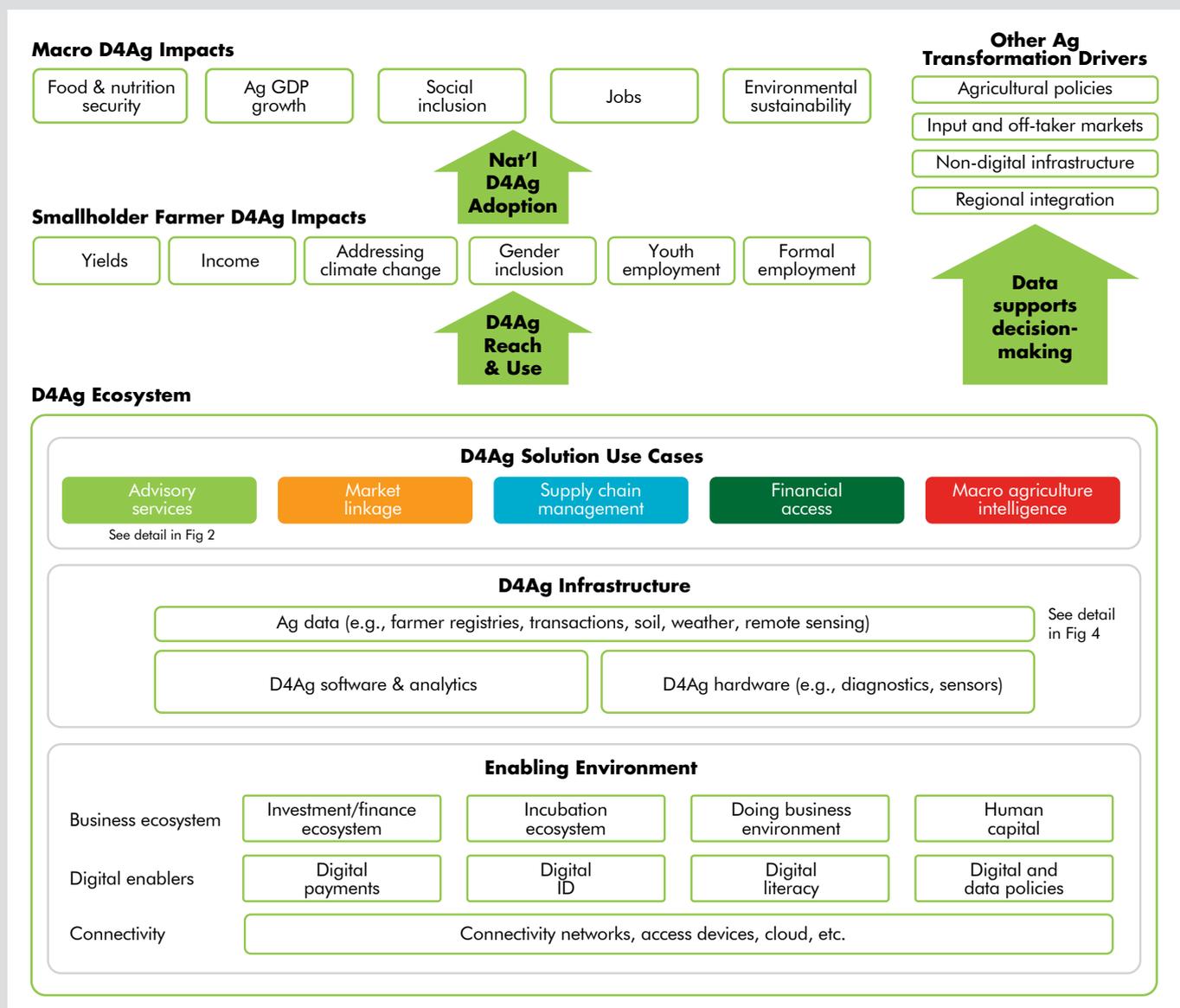
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D4Ag infrastructure (also sometimes referred to as D4Ag ‘middleware’ or ‘midstream technologies’) is the most immediately important element of the D4Ag ecosystem for ensuring the scale-up and impact of D4Ag solutions. As illustrated in Figure 4, this infrastructural layer includes enabling software and analytics tools, hardware that captures data fed into agriculture data systems (e.g., drones; weather stations; soil, pest, and crop diagnostics equipment; and field sensors) and a wide variety of data assets and systems relevant for smallholder farmers and farms.

Agriculture data systems cover all the factors that might inform D4Ag solutions, including **farmer data** (e.g., farmer registries that uniquely identify farmers and capture details on farmers and their



Figure 3 D4Ag ecosystem map

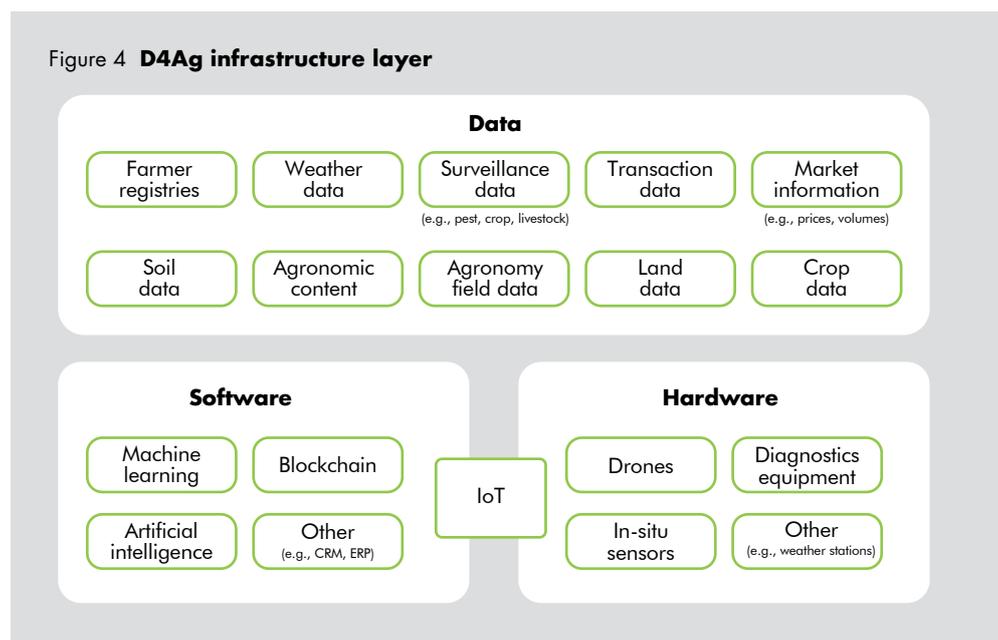


farms), **agricultural transaction and financing data** from commodity exchanges, marketplaces or financial institutions, **land registry data** (e.g., land title registries and other data assets and tools that geospatially mark farmer’s fields and their boundaries), **localised market data** on the prices of essential inputs and commodities, **soil data** (e.g., granular, national-scale soil property maps), **pest and disease surveillance data**, **localised weather/climate data**, **sensor data** from sensors embedded in farmers’ fields and agricultural machinery, **remote sensing data** (e.g., satellite and drone field maps),

agronomic data (e.g., field trial and field yield measurement data) and, finally, **agronomic good practices content** adapted to local crops and agroclimatic conditions.²⁰

Successful D4Ag solutions – particularly those that are customised to a farmer’s needs – are highly dependent for their impact and scalability on the availability, quality and cost of such agriculture data. Agriculture data systems at national and regional levels, however, are often underdeveloped, fragmented, low quality



Figure 4 **D4Ag infrastructure layer**

or entirely unavailable in most of Sub-Saharan Africa today. Without these data layers, D4Ag solutions can exist (and, of course, do exist), but are unable to realise their full potential to respond to the specific needs of each smallholder farmer at sufficiently low cost and with sufficient quality of data-enabled insights.²¹ We return to this topic in Chapter 5 when the report explores some of the major outstanding challenges and investment gaps to D4Ag solution scale-up.

The data layer, in turn, relies on and interacts with underlying layers of hardware and software tools that are either specific to the agriculture sector or adapted to the needs of smallholder farmer agriculture in the developing world. Hardware facilitates data acquisition and storage while software facilitates its processing.

Essential **D4Ag hardware infrastructure** includes agronomic diagnostics equipment (e.g., new types of portable soil, crop and agriculture input testing tools), remote surveillance systems adapted for agriculture (e.g., agriculture-focused satellite networks and drone surveillance providers with specialised soil and crop sensors), low-cost hyper-local weather stations and ‘in situ’ sensors (e.g., farm field sensors, agricultural machinery sensors

and logistics sensors embedded in post-harvest transport and cold chain equipment).

Critical **D4Ag software infrastructure** includes a wide range of field data collection tools, agent field-force management tools, data analytics tools, and software building blocks (e.g., blockchains for agriculture, AI chatbot tools and machine learning algorithms, background enterprise resource planning (ERP) and customer relationship management (CRM) modules). At the intersection of hardware and software sit sophisticated new internet of things (IoT) solutions for smallholder agriculture that integrate sensor data with analytics, monitoring and remote management tools.

Beyond the availability of essential D4Ag infrastructure, D4Ag solutions rely on the broader enabling environment for digital ecosystems. The overall enabling environment drives access and use of the D4Ag solutions, ensures the creation and growth of strong business models and creates a safe environment for users. The enabling environment includes connectivity, digital enablers and the business ecosystem.

First and foremost, D4Ag enterprises rely on the reach, capacity and quality of connectivity infrastructure. This includes the penetration and accessibility of



communication networks and devices – in order to access smallholder farmers and scale solutions. While many D4Ag enterprises have designed tools that farmers can use with simple feature phones via USSD, SMS and IVR, other D4Ag business models depend on greater reach of connectivity for people and devices (e.g., models reliant on connected field sensors), improved bandwidth (e.g., for models that involve video content and other data-intensive applications), lower cost of connectivity and much broader availability of smartphones (e.g., solutions reliant on smartphone functionality for field diagnostics of pests and diseases or soils). Another part of this connectivity layer are cloud services and other back-end systems that allow D4Ag enterprises to better leverage data and process information, forming a basis upon which to build more sophisticated solutions.

D4Ag solutions also depend on broader digital ecosystem enablers. National-scale digital payments systems, national digital ID infrastructure, digital literacy promotion efforts, and conducive digital and data policies, particularly with respect to cybersecurity and data privacy governance – are important elements of any well-functioning digital economy and thus critical to supporting the success, scalability, and sustainability of D4Ag initiatives. For example, a large share of D4Ag solutions in Africa today are at least partly dependent on or are building on the success of existing digital payments systems such as M-Pesa.

Finally, the overall business ecosystem is an important determinant of the success of D4Ag solutions. This broader business ecosystem includes human capital infrastructure and related educational systems that, ideally, support the promotion of general literacy and help supply the talent for product developers, agronomists, and field agents on which many D4Ag solutions rely. The investment/finance ecosystems support the availability of investment for D4Ag enterprises as well the broader financial systems and institutions upon which D4Ag players can

build their digital finance products. The incubation ecosystem, most notably local technology incubator and accelerator hubs, are often critical to the growth of early-stage D4Ag enterprises and the upskilling of young D4Ag entrepreneurs in Africa. Finally, the overall ‘Doing Business’ environment includes factors such as business registration, taxation and investment regulations, all of which affect the work of D4Ag enterprises.

While we firmly believe that D4Ag infrastructure and broader enabling environment elements are critically important for the success over the overall D4Ag ecosystem, these more upstream D4Ag ecosystem elements are not the focus of the analysis in the report and warrant separate treatment in future research publications. We do, however, touch on the status of these enablers to the extent that they help or hurt the evolution of D4Ag solutions in Chapters 4 and 5 of this report.

D4Ag Solution Use Cases – Overview of the Solution Landscape

The primary units of analysis for this report are the D4Ag use cases and underlying solutions. Figure 5 provides an overview of major examples of D4Ag solutions; the discussion that follows explores each use case in turn.

Advisory and Information Services Use Case

Digital farmer advisory and information service solutions offer on-demand (pull) or periodically distributed (push) information and guidance to farmers with the objective of helping smallholders adopt better practices – ranging from the types of inputs they should consider to agronomic techniques, post-harvest handling/processing and marketing advice, and overall farm business management tips. In addition to distributing information to farmers, like most other D4Ag use cases, D4Ag advisory



OVERVIEW OF THE SOLUTION LANDSCAPE

Figure 5 D4Ag solution use cases and illustrative sub-use cases

Advisory services



- Participatory and peer-to-peer
 - Digital Green
 - FARM ERK
 - we farm
- Farm management software
 - DigiCow Daily App
 - Probita Farmis.com
- Farmer information services
 - 8028 FARMERS HOTLINE
 - iCOW
 - AGRI-HELP
 - orange
 - viamo
- Precision ag advisory
 - UjuziKilimo
 - Precision Agriculture for Development
 - ASTRAL AERIAL
 - WATERWATCH COOPERATIVE
 - zenvus
 - agrocared

Market linkage



- Digitally-enabled value chain integrators
 - TULAA
 - Twiga
 - DigiFarm
 - Cowtribe
 - agrics farm inputs credits
 - AKORION
- Food e-commerce
 - Jinukun
- E-marketplaces
 - Usomi
 - FARMSTER
 - efarm.cm
 - zowasel
- Mechanisation access services
 - TROTRON Tractor Leasing
 - hello tractor
 - sun culture
 - TinCA

Supply chain management



- Traceability
 - Sourceface
 - ChainPoint
- Quality assurance
 - QualiTrace
- Logistics
 - logistimo
 - iProcure
- Supply chain ERP
 - farmforce
 - SAP
 - eprod
 - mfa:ms Agribusiness Solutions
 - Cropin

Financial access



- Payments
 - cellulant
 - SM
 - ZOONA
 - AgroPay
 - AGRI-WALLET
- Crowd-farming
 - farmcrowdy
 - LIVE STOCK WEALTH
 - thrive
- Savings
 - m
 - akabon
- Insurance
 - acre AFRICA
 - PULA
 - WorldCover
- Credit
 - ADVANS Growing together
 - kics
 - msoni
- Fin analytics
 - APOLLO
 - FarmDrive
- FSP digitalisation
 - HARVESTING
 - VAPU
 - ensibuuko

Macro agriculture intelligence



- AG OBSERVATORY
- 6grain
- CGIAR Platform for Big Data in Agriculture
- ARO
- aWhere
- CubicA
- ACRE



ADVISORY AND INFORMATION SERVICES

Figure 6 **Advisory services – sub-use case overview and examples of solutions**



Advisory services



and information services solutions often include intensive data collection from farmers in order to improve the quality and relevance of the advice and information they deliver and, at the same time, to generate a flow of valuable data back to agribusiness, public/NGO extension systems and, in rarer instances, the agronomy R&D community.

These types of services, which are delivered either directly to farmers' phones or with the support of intermediaries like extension agents, financial agents, and agribusiness field forces can play an important role in helping smallholders improve their yields and thereby increase overall productivity, income, and food security.

Over the past several years, advisory services have become far more sophisticated. Historically, digital farmer advisory and information services have focused on packaging and delivering generic best practices to farmers. More recently, by better tailoring information and advice for individual farmers, improving the quality of the content they deliver, continuously lowering the costs of service delivery, bundling advisory solutions with other higher margin services like market linkage, and finding new partnership models for scale (e.g., by partnering with mobile network operators (MNOs), governments, and agribusinesses), a growing number of advisory solution providers have achieved dramatically increased farmer registrations, deeper farmer engagement, and in some instances stronger economics (though, as discussed in Chapter 3 of this report, the economics for many D4Ag advisory services enterprises still remain precarious with limited per farmer revenues and razor thin or negative margins in the absence of subsidies).

Advisory services can be sub-segmented into different sets of often overlapping categories. Some major sub-types of advisory solutions worth highlighting are **farmer information services, precision agriculture advisory, participatory**

advisory, and self-service farm management solutions.

Advisory Services – Farmer Information Services

Farmer information services provide relatively general agricultural

information and advice on agronomic best practices (e.g., planting, harvesting, pest and disease management), farming inputs, the weather, and market information (e.g., prices for key inputs and commodities), typically via SMS, USSD, and IVR, and occasionally with call centre support. Recommendations are not traditionally tailored beyond national levels or general crop types. Farmers access the advice and information directly, as is the case for most advisory service solutions tracked in this report, or via agents such as government extension officers, NGO staff, agribusinesses agents, financial service provider agents, and lead farmers. In such intermediated models, agents use digital advisory tools and information repositories to deliver support to individual smallholder farmers or farmer groups.

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These farmer information services constituted the majority of the early wave of ICT4Ag innovators in Africa a decade ago. They are exemplified by enterprises like **Esoko** in Ghana (in its earlier stages),²² **Grameen Foundation's Community Knowledge Worker (CKW)** solution in Uganda,²³ many early donor-funded 'e-extension' agriculture projects from NGOs like **Catholic Relief Services (CRS)**, and most of the initial MNO-linked agriculture value-added service (mAgri VAS) solutions²⁴ like **Tigo Kilimo** in Tanzania and **M-Kilimo** in Kenya. Many such solutions from that first wave of innovators are currently defunct.

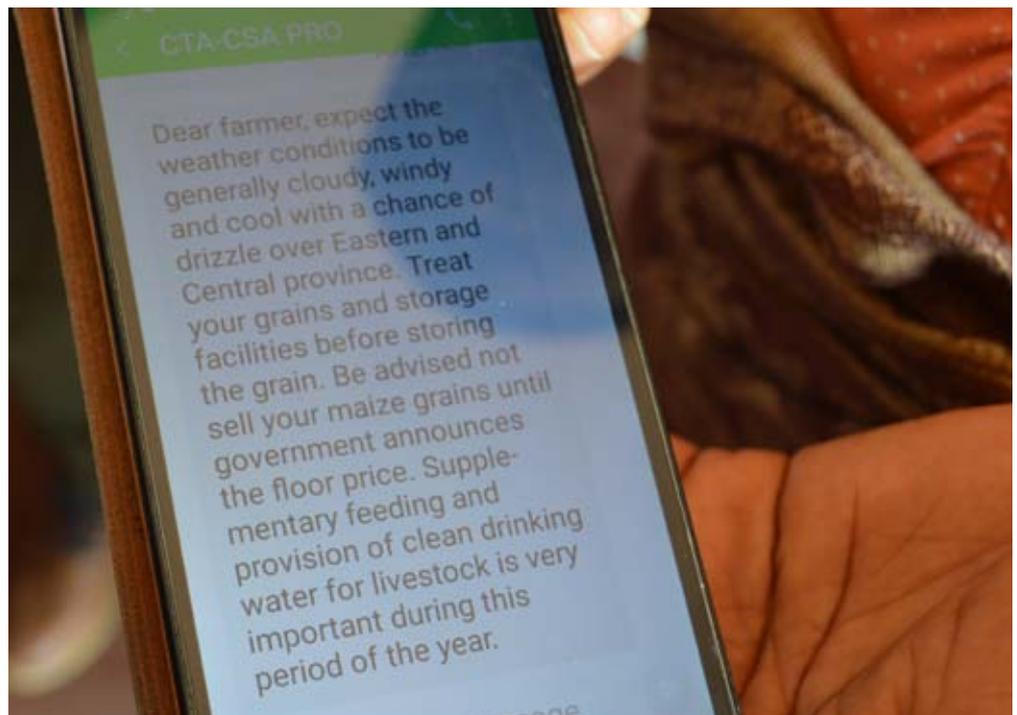
A large share of existing digital advisory service solutions can still be classed as farmer information services today; this category includes many of the largest D4Ag solutions in Sub-Saharan Africa in terms of the number of smallholder farmers reached (i.e., registered for the solution). Typically, such solutions have significantly evolved their business models from first-generation farmer information services. For example, they have moved toward delivering more tailored information

(i.e., informed by the GPS location of the farm and other specifics of the smallholder client), have greater focus on weather and climate information, and have the tendency to bundle other services, such as market linkages, alongside farmer information. Most of the players in this category also now have diversified revenue models beyond the farmer usage fees and donor subsidies that were typical of earlier solutions. They now tend also to pursue commission fees and data monetisation revenues from agribusinesses and, in some cases, cost coverage or cost-sharing from MNOs interested in adding value to their smallholder farmer customers.

Examples of current farmer information system solutions include a few different models such as large-scale government-run farmer information services.

Examples of such solutions include the **80-28 Farmer Hotline** in Ethiopia that is managed by the country's Agriculture Transformation Agency (ATA),²⁵ **ZIAMIS** in Zambia,²⁶ Kenya's Agriculture and Livestock Research Organisation's (**KARLO**'s) suite of farmer applications,²⁷ and the **Smart Nkunganire System (SNS)** in Rwanda.²⁸

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MNO-led or MNO-linked farmer information services represent another major sub-category. There are more than two dozen such solutions in Sub-Saharan Africa, with the most notable examples being **Viamo 3-2-1** information services, deployed in partnership with various MNOs across the continent, and **Orange's D4Ag** services portfolio. Each of these have farmer information services in more than 10 Sub-Saharan Africa countries.²⁹ Examples of country-specific solutions in this category include **Econet's EcoFarmer** in Zambia.

Other important examples with significant scale are specialised farmer information system enterprises like **iShamba** in Kenya;³⁰ **iCow** in Kenya, Tanzania, and Ethiopia;³¹ **Verdant Agritech** in Nigeria;³² **Farmerline's 399 Service** in Ghana;³³ SMS-based market price dissemination services like **RATIN**,³⁴ and several market information services solutions that are linked to commodity exchange platforms like the **Ethiopia Commodity Exchange (ECX)**.³⁵

Advisory Services – Precision Advisory

Precision agriculture advisory services represent a second major emerging cluster of solutions under the advisory services use case. Precision agriculture, in the context of digital advisory services, implies a move from offering generalised best practices to disseminating recommendations that are highly tailored to individual farmers, farms, and, ultimately, farm fields. What this means practicably in the African D4Ag smallholder context often remains vague.³⁶

Precision advisory customises information selection and recommendations based on a large number of factors. Precision advisory services tend to factor in agronomic features of specific farm fields (e.g., soil properties, water availability, shade levels, intercropping



Espace Géomatique, Burkina Faso

patterns), local pest and disease trends, and highly localised, granular weather data and related on-the-ground agroclimatic information such as field temperature, precipitation, and moisture levels. They can consider the specific crop varieties grown on the farm (i.e., advice, informed by crop models, is calibrated to the specific varieties in use on the farm rather than more general crop behaviour models imported from other contexts). They can also take into account the demographic profile of the smallholder household (e.g., the household's budget constraints, risk appetite, level of farming skill, and level of literacy). Finally, though such solutions are few today, they can look at the microeconomic setting of the farm (e.g., geographically proximate input prices, market prices, and market distances that affect the farm's economics).

A sufficient quantity and quality of data must be captured in order for precision advisory services to function effectively. This first requires that individual smallholder households and farmers be profiled in detail and that farm fields and field boundaries be geo-tagged. The resultant data must then be integrated with other data derived from such sources as the remote surveillance of farm





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fields through drone and satellite imaging, granular weather surveillance, and hyperlocal weather sensors. In addition, new types of portable diagnostic equipment and analytics can be applied for in-field pest, disease, soil, and crop nutrient testing. For the greatest precision, in situ sensors can be deployed in smallholder fields and on farm machinery like irrigation and tillage equipment to provide ongoing real-time monitoring.

The use of such localised data on smallholder farms theoretically allows for highly tailored advice on planting, irrigation, and harvesting times, the selection of the most appropriate farm inputs like seeds, fertilisers, and pesticides/herbicides, and forward-looking farm planning that considers precise (and dynamically updated) estimates of crop yields and market conditions. Taken to the extreme of their potential and granularity, precision advisory models can also allow farmers to optimise within their fields by informing variable application of irrigation and other inputs like fertilisers and pesticides for specific portions of a field.

No current solutions on the ground in Sub-Saharan Africa incorporate all possible elements of precision advisory services, but dozens of players are starting to experiment with such

approaches. Since the concept of precision advisory sits on a spectrum from moderately to highly customised advice, in some cases, the boundary between farmer information services and precision advisory services can be blurry. This is all the more true as traditional farmer information solutions, like those provided by MNOs, increasingly incorporate localised crop, weather, and pest data into advisory algorithms. Nonetheless, a few emerging models can be classified as having elements of precision advisory services.

At the somewhat less precise end of the precision advisory spectrum are weather/climate and pest and disease early warning surveillance and advisory services. These focus on integrating localised and real time weather and/or pest and disease data in combination with basic information about the client farmers' or pastoralists' locations and agricultural practices. Examples of weather surveillance advisory solutions include CTA and aWhere's **CLIMARK** weather information service for pastoralists in northern Kenya and southern Ethiopia,³⁷ CTA's project with **ECONET** in Zimbabwe delivering ICT-enabled weather information services, **Ignitia's Iska** weather forecast services in West Africa,³⁸ **World Vision's EWEA/FIS** early warning platform in Mali,³⁹ and **Weather Impact's** weather-based





smallholder farming advisory products in Kenya, Ethiopia, Burundi, and South Africa.⁴⁰

For pest and disease surveillance, specifically, there are a growing number of pest-specific solutions (e.g., **Boa Me** in Ghana, **Rise Africa** in South Africa, and **Nuru** in Kenya for the fall armyworm⁴¹), as well as large-scale multi-crop solutions like **CABI's Plantwise**⁴² and the **Waterwatch Cooperative's Crop Disease Alert** application.⁴³ A number of solutions like **WeatherSafe's** Coffee Crop application in East Africa⁴⁴ and **AgriPredict** in Zambia⁴⁵ are focused on both weather and plant disease surveillance and risk management.

Another category of solutions moving toward greater precision are remote sensing (satellite) advisory services that provide advice to smallholders based primarily on satellite image analysis combined with in-depth farmer profiling, weather modelling and, at times, soil data.

Such solutions frequently also provide climate adaptation and pest and disease advice but have broader mandates than the weather and pest surveillance systems covered earlier, since these solutions primarily focus on geographically-targeted advice on crop and livestock management practices and/or

tailored input advice like highly customised fertiliser formulations. Examples of such solutions are **Sat4Farming** in Ghana,⁴⁶ **Earth-I's ACCORD** project in East Africa,⁴⁷ the **Orange Garbal** solution in Mali,⁴⁸ **Geodatics** in Kenya,⁴⁹ **MUIIS** in Uganda⁵⁰ and agribusiness-focused (B2B) players like **CropIn** and **SatSure** which deliver precision advisory services to smallholder value chains.⁵¹

Another interesting example, though the organisation positions itself much more broadly in its ultimate aspirations and technology focus, is **Precision Agriculture for Development (PAD)**. PAD is a global NGO focused on integrating greater precision into digital smallholder advisory extensions with the support of remote sensing data, other data such as weather patterns and soil types, behavioural science techniques (for solution design and testing), and rigorous evaluations (i.e., randomised controlled trials (RCTs)) of resulting advisory outcomes.⁵² Satellite imagery analytics are the cornerstone of PAD's precision advisory solutions in Africa.

A related sub-group of precision advisory players are drone surveillance advisory specialists; CTA and Dalberg are tracking over thirty such solutions in Sub-Saharan Africa. These actors integrate drone imagery with other data sources to

Neil Palmer, CIAT



develop and disseminate customised farmer advice. Examples of such solutions include **Astral Aerial** in Kenya, **AgrInfo Jembe** in Tanzania, **Charis** in Rwanda, **AcquahMeyer Drone Tech** and **Ziongate Geospatial's Airborne Agric** solutions in Ghana, **ThirdEye** in Mozambique, and **WeFly Agri** in Côte d'Ivoire.⁵³ Like most drone players in Africa, these solutions tend to be of very recent vintage; most are in the early stages of testing and developing their farmer advisory services into products, as well as developing viable business models.

Soil and crop diagnostic advisory services are another emerging cluster of precision advisory solutions. These rely on soil or crop diagnostics as an entry point into the farmer relationship, and typically combine soil and crop data with other information about the farmer and farm to generate tailored advice.

Some of these solutions do not require any specialised equipment but rely on the processing of images taken via smartphone applications. The background data analytics enabled by machine learning across large datasets of field images and ground-truth data allow such solutions to remotely facilitate yield measurements, assess nutrient deficiencies, or diagnose pests and diseases. Examples include the **Yara International ImageIt** application for diagnosing plant nitrogen deficiency,⁵⁴

PlantVillage's Nuru cassava disease diagnostics application,⁵⁵ the **Grainotheque Yiri Drotro** fruit and vegetable crop disease diagnostics solution in Côte d'Ivoire,⁵⁶ and **PEAT's Plantix** application (the most notable example globally of such solutions in terms of both sophistication and scale).⁵⁷

More complex variants of diagnostic advisory solutions are models that involve agent-intermediated field diagnostic or rely on new types of portable or farm field sensors.

Agent-based diagnostic models include solutions like **CropNuts' Daktari Wa Udongo** product in Kenya, which features the collection of soil or crop samples in the field by plant doctors or, alternatively, the training of farmers to self-collect and then test soil and crop samples in a professional lab before developing and delivering customised advice to farmers' phones via SMS and IVR.⁵⁸

As alternatives to diagnostic lab infrastructures, some solutions rely on novel portable diagnostic tools. Examples include the **Agrocares** soil and crop scanner and advisory application,⁵⁹ **Croptix's** mobile smartphone-compatible spectrophotometer for plant health advisory,⁶⁰ and **Zenvus's Yield Sky**, a portable hyperspectral camera for smallholder farmers that feeds into Zenvus's precision advisory solution.⁶¹ Some examples of enterprises that use field/in-situ sensors for ongoing real-time diagnostics include **Ujuzi Kilimo**,⁶² **Lentera**,⁶³ and **SunCulture**⁶⁴ in Kenya and **Zenvus' SmartFarm** sensor in Nigeria.⁶⁵ Field sensor-based precision advisory for smallholders is also an area of increasing experimentation by large technology companies. Examples include **IBM's EZ Farm**⁶⁶ and **Microsoft's Farmbeats**,⁶⁷ with several pilots in Sub-Saharan Africa, particularly centred on Kenya.

The general trend across many of the precision agriculture advisory solutions in Africa, particularly as the costs of underlying technologies decrease,

Ujuzi Kilimo



is toward fully integrated precision advisory platforms. Such platforms combine in-depth farmer profiles, transaction data, weather data, satellite data, drone data, and field/machinery sensor data. Such integrated D4Ag products could ingest immense amounts of data about farmers and farm fields in order to generate highly tailored and dynamic advice regarding every element of farm operation.

While still in their early stages, such next-generation integrated precision advisory solutions for smallholder farmers already exist and are being deployed by big technology players.

Examples are **Microsoft's Farmbeats** (and related Digital Agriculture Platform) in Kenya and the **Tata Consulting Services (TCS) InteGra** precision agriculture advisory platform in South Africa.⁶⁸ Precision agriculture D4Ag start-ups like **AgrInfo/Jembe** in Tanzania, **Zenvus** and **Kitovu**⁶⁹ in Nigeria, **Lentera** in Kenya, and **CropIn**, are moving in a similar direction, combining soil data, farmer data, field sensors, and remote sensing data from satellites and drones.

Advisory Services – Participatory and Peer-to-Peer

Participatory and peer-to-peer advisory solutions are another important sub-type case of digital advisory services.

Participatory solutions feature tight feedback loops between content providers and end-users, greater levels of farmer interactivity with the solution (i.e., not just one-way information flows from experts to farmers), and, in many cases, a role – direct or indirect – for farmers in creating or customising advisory content. Peer-to-peer advisory solutions share some of these features, but also put individual farmers and farmer experts into more central roles for content creation and dissemination.

Broadly speaking, digital advisory solutions are moving toward greater interactivity, localisation, and adaptation



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of content. As in the case of precision agriculture and farmer information services, it is often difficult to draw hard boundaries between participatory solutions and other types of digital advisory services. Increasingly, solutions rely on end-user feedback and multi-directional data flow rather than taking more rigid, top-down architectures to information dissemination.

For instance, many digital advisory solutions over the years have integrated inbound and outbound call centres and IVR models to source queries from farmers and deliver tailored advice in local languages. This form of interactivity can be considered part of the participatory advisory sub-use case, though it also overlaps with other advisory models mentioned above.

Multiple D4Ag solutions feature call centre models that ensure a high degree of interactivity. This interactivity manifests both in the nature of call centre engagement with farmer clients and in the adjustment of content based on rigorous data capture and analyses of incoming queries. Examples include a number of current advisory solutions, such as **iShamba** in Kenya, the **80-28 Hotline** service in Ethiopia, and **Farm Radio's Mlimi Hotline** in Malawi.⁷⁰





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Likewise, the use of IVR tools – either in combination with call centres and SMS channels or via stand-alone channels – is now mainstream for digital advisory solutions in Africa.⁷¹ There are too many models that integrate IVR to mention, but it is worth highlighting the work of IVR technology pioneers in the agriculture advisory space like **Awaaz.De**, **VotoMobile** (now part of **Viamo 3-2-1**), and **EngageSpark** who offer B2B IVR-integration services to D4Ag enterprises.⁷² In addition, a couple of the most notable large-scale IVR-based advisory solutions are the **Ethiopia 80-28 Hotline** and **Viamo's** network of IVR-based 3-2-1 Farmer information services.

Newly arrived in the interactive advisory model space are chatbots for D4Ag service delivery. These will become increasingly common over the next few years. A growing number of solutions are integrating machine-learning/AI-enabled chatbots, a trend that all experts consulted for this report expect to accelerate in the next few years. Chatbots are programmes designed to simulate natural conversations with human users – in this case, with farmers – either via text or voice-based applications. These models offer multiple theoretical advantages including greater farmer engagement with the content, the ability to

dynamically mine farmer queries to improve content relevance and delivery, and the ability to tap into large volumes of farmer-generated content (e.g., logs of prior conversations) to enrich the breadth, depth, and localisation of the advice being delivered.

A couple of noteworthy examples include **Arifu**, a large digital learning and advisory service that works with African farmers via SMS and chatbot applications⁷³ and the chatbot-based advisory platform in Kenya, **Farm.ink** (and its associated **Africa Farmer's Club** Facebook community).⁷⁴ Another interesting solution in this category is **Mahindra & Mahindra's MyAgriGuru** voice chatbot for smallholder farmers. Though this solution is currently limited to India, it is reaching substantial scale and will likely be replicated in some way for Africa's farmers.⁷⁵

D4Ag advisory solutions do not merely exploit new models for farmer interaction but also, in some cases, integrate farmer-generated or intermediated content. The most established example of such a peer-to-peer advisory model is **Digital Green**, one of the veteran enterprises of the D4Ag sector, which for over a decade has deployed its farmer video model on a large scale first in India and now also in several countries in Africa. This solution features (i) a participatory process for content production (i.e., topic selection and content adaptation informed by farmer feedback); (ii) locally generated digital videos filmed by specially trained community film-makers and, even more critically, featuring local farmers who demonstrate and promote improved agricultural practices in local languages; (iii) human intermediated instruction of farmer groups for content dissemination and training (i.e., a private company, NGO, or government extension agent shows videos to farmers and facilitates discussions); and (iv) intensive and systematic data capture and analysis of farmers' feedback about the solution content and their resulting behaviour changes. The Digital Green model has been studied closely over the years,



but the crux of the approach, relevant for this discussion, is the participatory nature of the solution both in terms of the content itself and the process of farmer engagement, behaviour change, and practice adoption.⁷⁶ Digital Green's model involves farmers in content development, but the content is also carefully curated, screened, and triangulated with input from professional agronomists.

Other peer-to-peer advisory models link farmers with each other directly, so that one farmer's questions are answered by another. This approach creates tremendous opportunities for on-the-ground data collection and for impacts on farmer behaviour (i.e., farmers engaging more with content that is validated and shared by their peers). But, like any social networking solution with limited curation, it simultaneously presents significant risks that low-quality or inaccurate agricultural advice and information can be collected and distributed based on crowdsourced perspectives or direct farmer-to-farmer advice.

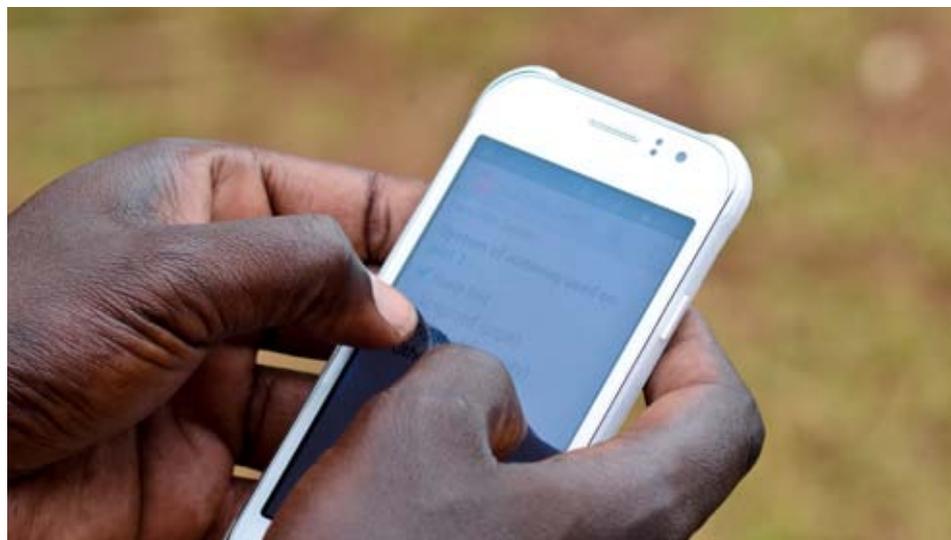
A few different solutions exemplify the peer-to-peer approach. **Africa Farmer's Club/Farm.ink**, already noted above in the context of the **Farm.ink** chatbot, for instance, relies on a Facebook farmer community that generates farm queries and content that the chatbot can mine and pair with professionally curated agronomic content.

Wefarm, the largest-scale peer-to-peer farmer social network in Africa, takes a different approach.⁷⁷ Wefarm users can ask and answer farming questions and share farming tips, via SMS or online, enabling farmers in rural areas without internet access to participate. **N-Frnds**⁷⁸ gives farmers access to professionally curated advisory content on its platform via feature phones (USSD), allows for interaction and communication between business owners, suppliers, and farmers, and includes highly popular features that allow farmers who lack mobile data to engage in group and one-on-one chats to share farming advice.

Smallholder farmers are also increasingly using major social networking platforms to communicate agricultural information. It is important to highlight, with respect to peer-to-peer D4Ag solutions, that in those geographies where there is sufficiently strong connectivity, the top social media platforms in Sub-Saharan Africa – i.e., Facebook, Facebook Messenger and, to a greater degree, WhatsApp – are becoming increasingly important farmer-to-farmer information sharing vehicles.⁷⁹ This phenomenon is still marginal in many places, but as the adoption of mainstream social media and communication platforms like WhatsApp increases and as such platforms widen their functionality (e.g., WhatsApp's widely anticipated move into payments), the potential for such networks to become major channels for advisory and other D4Ag service delivery will grow. In Kenya, for example, a country where the level of WhatsApp adoption is already very high by African and even global standards,⁸⁰ an expansive, late-2018 smallholder survey showed that WhatsApp was already used for farming by half as many farmers as those who used farming apps.⁸¹

Advisory Services – Farm Management Software

Farm management software solutions for smallholder farmers feature interactive tools/applications for farmers CTA



or agents interfacing with the farmers that go beyond the delivery of tailored recommendations to specific farms.

They empower farmers to make their own decisions with tools to (i) farm budgeting and planning (e.g., pro forma upside implications and risks of specific farm investments based on market conditions and/or historical farm performance); (ii) farm monitoring (e.g., dynamic yield and economic projections); (iii) financial management, accounting, and record-keeping; (iv) supply chain management in the case of slightly bigger or more complex smallholder farm operations; and potentially even (v) reporting tools that can pave the way to formal financing.

While there are many sophisticated farm management software solutions for large-acreage farms in the developed world, the segment of D4Ag services for smallholders is understandably very nascent. African smallholder farmers face significant literacy and digital literacy constraints that curb the potential reach of highly interactive farm management software. Furthermore, access to mobile data and/or sufficiently sophisticated devices like smartphones, tablets, and laptops is limited. At the same time, particularly in the context of livestock and dairy, interesting solutions are starting to emerge. Some recently launched

examples include **SmartCow**⁸² and **DigiCow**⁸³ in Kenya for dairy cows, and **AkokoTakra**⁸⁴ in Ghana and **Sen Ngunu**⁸⁵ in Senegal for poultry. For smallholder horticulture and staple crop farming, examples of such self-service management solutions include African start-up D4Ag enterprises like **Probita Farms**⁸⁶ in Nigeria, **AgriGo**⁸⁷ in Rwanda and **BudgetMknoni**⁸⁸ in Kenya, as well as international farm management solutions like **AgriVi**,⁸⁹ which can be utilised by African smallholders and are being marketed through local partners in several countries, such as Kenya and Nigeria.

The reach of most of these solutions is still very limited given how new they are and given the broader challenges noted above for smallholder uptake of more sophisticated self-service software. Our interviews suggest, however, that the uptake and abundance of such solutions will grow quickly in specific niches such as dairy. Even in the area of staple crops and horticulture, while complex farm management tools will likely see low uptake in near term, novel D4Ag farm budgeting and recordkeeping features could become far more mainstream as smartphone adoption increases.

Market Linkage Use Case

Most African smallholder farmers are not adequately linked to markets for a variety of reasons. These include information gaps and asymmetries about market needs, buyers, and prices; remoteness (and related challenges of logistics and transportation costs); overly low and geographically fragmented production volumes to interest bigger buyers; poor quality of produce relative to market requirements or difficulty in meeting the high hurdles of food safety standards and traceability required by agribusiness buyers and processors in more commercial value chains; and, critically, low farmgate prices due to highly intermediated value chains with multiple layers of actors between farmers and end-consumers. On the input market side, beyond challenges of

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MARKET LINKAGE

Figure 7 Overview of D4Ag market linkage models



financing access, smallholder farmers also have difficulty finding and purchasing reliable and appropriate farm inputs due to some of the same factors – including information asymmetries about which products are appropriate and have sufficient quality, diseconomies of scale and a related lack of buying power, underdeveloped and fragmented agro-dealer networks that increase input costs but still offer very limited availability and convenience for input purchases at the last mile, and other logistics and distribution challenges that are common in rural Africa.⁹⁰

Digitally-enabled market linkage solutions thus have a critically important role to play in connecting smallholder farmers to high-quality farm inputs, to production and post-harvest machinery and mechanisation services, and – ultimately – to off-take markets, including agro-dealers, wholesalers, retailers, or even directly to the urban or international end-customer. Digital market linkage solutions, by introducing efficiency, transparency, accountability, and trust into otherwise inefficient and opaque value chains, allow smallholder farmers to lower their costs of production via access to lower-cost and higher-quality inputs, reduce the costs and risks of finding and transacting with buyers and ultimately increase their yields and farm incomes – while at the same time helping

agribusinesses of all types improve their margins and grow markets.⁹¹

In the past several years there has been significant growth in the number of digital market linkage solutions available, as well as the scale of those solutions. As with many other D4Ag use cases, however, given the nascency of the sector and rapid evolution in terms of technologies and business model, the definition of ‘digital market linkage’ remains amorphous. The term is often applied loosely to describe an ever-multiplying array of business models.⁹²

The crux of the concept is the use of digital tools to facilitate market connections, which ultimately lead to transactions for goods or services between different smallholder value chain actors including farmers; farm aggregators such as cooperatives, agri-input producers and input distribution intermediaries; farmer services providers (e.g., veterinarians, agronomists, mechanisation services providers, financial institutions); produce buyers, traders, and processors; and – moving toward the ultimate end-consumer – international exporters, domestic wholesalers and retailers of finished food products.

At the most basic level, digital market linkage solutions can be segmented by both their **value chain role** and by their **level**

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of human intermediation. The former considers their input market linkage, off-take market linkage or end-to-end market linkage. The latter ranges from purely digital solutions like virtual agriculture commodity e-marketplaces and trading applications to digital tools and platforms that function only in combination with last-mile human agents working either for the D4Ag enterprise or for agribusiness organisations that are themselves agriculture value chain participants as aggregators, buyers or sellers. Another important consideration is the **breadth of the overall value proposition**, i.e., market linkage only versus models that combine market linkages with advisory services, supply chain management, and finance. There are, of course, a myriad of other nuances that differentiate digital market linkage business models – such as revenue models and contracting arrangements – which this report does not explore.

Across these dimensions, four major clusters of digital market linkage models stand out in the Sub-Saharan African market today: digitally-enabled

value chain integrators, mechanisation access services, agri-input and food e-commerce services, and virtual buyer-seller e-marketplaces (Figure 7).

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Market Linkage – Digitally-Enabled Value Chain Integrators

Digitally-enabled value chain integrators are D4Ag solutions that use digital tools combined with either in-house or third-party human agents to link agricultural markets. At the core of these models is the ambition to capture value and generate impact for both smallholder farmers and agribusinesses by formalising currently fragmented and informal value chains. Value chain aggregation and formalisation can, of course, be accomplished via non-digital means, but the key insight of digitally-enabled value chain integrator solutions is that digital tools are a powerful means of improving trust, reducing costs, accelerating time to market (a critical consideration for seasonal and highly time-sensitive agricultural input and off-take markets), facilitating transparency





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and accountability, and ultimately growing the reach, social impact, and profitability of traditional value chain linkage models.

Largely anecdotal evidence suggests that these market linkage solutions generate tangible benefits such as greater ease in identifying and attracting farmers (i.e., lower acquisition costs), significantly reduced agent-to-farmer ratios (i.e., field force efficiencies), lower requirements for agricultural agent skills due to digital monitoring and information access (i.e., lower agent recruiting and training costs), improved trust for all parties (i.e., greater stickiness of farmers and other value chain actors to the solution), reduced value leakage in operations due to digital tracking (i.e., less agricultural product spoilage and loss and reduced input theft), and – critically – benefits from economies of aggregation and scale for value capture, whether in terms of lower input costs or higher produce prices.⁹³

The unique advantage of digital market linkages in general, and the digital value chain integrator solution sub-type in particular, is that in these models the D4Ag solution provider is an integral value chain player. By taking on bigger risks and making substantial investments in value chain formalisation, the solution provider is theoretically able to take a much bigger share of the value that is ultimately being generated at the point

in time that the value is generated (e.g., via commissions, revenue shares, or brokerage fees) in comparison to the much more indirect revenue models of most other D4Ag use cases.

Major variants of the digitally-enabled value chain integrator model include (i) input market integrators; (ii) off-take market integrators; and (iii) end-to-end value chain integrators.

There are already a few dozen solutions in this category today in Africa; the number is growing rapidly as new D4Ag market linkage start-ups enter the market and as traditional smallholder value chain integration actors – such as small/medium-sized agribusinesses, big regional or international agribusinesses, and specialist market linkage NGOs and social enterprises such as One Acre Fund and Babban Gona – integrate digital tools into their human agent models in order to reduce costs, improve profitability, and strengthen their competitive positioning vis-à-vis new digital disruptors.

While there are a few important exceptions, many of these players have relatively limited reach today. The main reason for this, beyond the newness of these models, is the resource intensity of these solutions and, in the case of off-take market linkages, the need to develop market demand concurrently with quality product supply – something that requires time. Nonetheless, solutions of this type are growing, can break even quickly and, as suggested in our interviews with sector experts, are likely to see growing attention from investors in the next few years.

For **digitally-enabled input market integrators**, digital technology primarily serves as a communication and transaction channel by which smallholder farmers and input providers (e.g., seed, fertiliser, pesticides/herbicides producers, large distributors, and last mile agro-dealers) coordinate on the quantity and type of inputs needed, aggregate farmer input demand to improve



the economics of input distribution, and optimise logistics (e.g., input delivery route planning). Notable examples of African start-up enterprises that fall into this category include **Farmers Pride** in Kenya,⁹⁴ **CowTribe** in Ghana,⁹⁵ **myAgro** in Mali and Senegal,⁹⁶ and **Agrics**⁹⁷ and **iProcure**⁹⁸ in Kenya and Tanzania.

While most of these digitally-enabled input market integration solutions are relatively small scale, some have significant reach or significant potential for near-term reach. For instance, **One Acre Fund**, the non-profit social enterprise that had more than 800,000 farmer clients in 2018 for its bundled input and financing approach, is already the largest-scale implementer in Africa of agent-intermediated smallholder input market linkages for non-commercial (loose) smallholder farmer value chains. **One Acre Fund's** model has historically featured little technology, but over the past few years the organisation has started to invest aggressively in integrating into its market linkage work a range of digital approaches and tools, from digital farmer registrations to digital agent field force management tools, digitally-enabled monitoring and evaluation and

mobile input loan repayments, among other digitalisation initiatives.⁹⁹ If it continues to follow this trajectory, **One Acre Fund** will, in effect, become a digitally-enabled input market linkage platform and may be able to convert these digitalisation investments into much greater impact and scale. Other models comparable to **One Acre Fund**, such as **Babban Gona** in Nigeria, are likewise investing heavily into digitalising elements of their input supply chain linkages approach.

From the perspective of more commercial models with potential for scale, **Safaricom's DigiFarm** is currently primarily focused on using a combination of digital technologies and its physical network of partner organisation field agents to link Kenyan farmers to agricultural inputs, along with input financing, and increasingly more tailored advisory services.¹⁰⁰ While the organisation and partners like MercyCorp's AgriFin Accelerate programme have a broader ultimate vision for **DigiFarm**, the solution is today a classic example of a digitally-enabled input value chain integration model with potential for scale.¹⁰¹

For **digitally-enabled off-take market integrators**, digital tools are likewise used



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to support the efforts of human field agents. The primary role of digitalisation for such solutions is to reduce the transaction costs of aggregating high-quality produce from highly fragmented smallholder value chains, thereby generating cost savings for agribusiness and incremental value to farmers due to greater certainty (or, via contracts, absolute guarantees) of market access, the reduction in the number of intermediaries between the farmer and the buyer, and farmers' improved bargaining position vis-à-vis buyers.

Leading digital off-take market integration solutions in Africa include **Twiga Foods** in Kenya, the best-known enterprise in this category given its tremendous fund-raising success in the recent years.¹⁰² In the D4Ag start-up space, important examples of digitally enabled off-take market integration solutions include a few Kenya-based players such as **Selina Wamucii**, **Farmshine**, and **Taimba**, as well as start-ups elsewhere on the continent like **Trade** in Ghana.¹⁰³

Finally, another example that has garnered a great deal of attention globally and is likely to be replicated soon in Africa is **Digital Green's LOOP**, a digitally-enabled

horticulture off-take market linkage solution currently being scaled as a for-profit enterprise in India.¹⁰⁴

A rising number of solutions use digital technology and human agents to link both sides of the market, from farm input provision through off-take – a model we label as integrated end-to-end market linkages.

In the start-up space, one of the most ambitious early-stage solutions of this type is **Tulaa** in Kenya, an innovative end-to-end market linkage enterprise that is seeing growing commercial investor interest and – based on early independent assessments of its market pilot in 2019 – is already generating significant per-farmer revenue and high levels of impact on smallholder yields and incomes.¹⁰⁵ Another interesting start-up example is **Akorion's EzyAgric** solution in Uganda, which combines digitally-supported input and off-take market linkages with a network of youth service provider village agents equipped with smartphones, each of whom serves 150–200 farmers as a facilitator of input and off-take transactions.¹⁰⁶

At a greater scale, the work of the **Farm to Market Alliance (FtMA)** is also a variant of this end-to-end approach, combining human-intermediated input and off-take linkages (and physical market aggregation infrastructure) with the increasingly rich feature set of FtMA's in-house digital platform.¹⁰⁷

Another entry point for digitally-enabled end-to-end market linkages in more commercial value chains are digital smallholder financing programmes of the type being pursued by the **Kenya Commercial Bank (KCB)** via its **Mobigrow** product in East Africa and by **Opportunity International** via its holistic smallholder value chain financing model in Ghana and Côte d'Ivoire.¹⁰⁸ At the core of both products is an approach that involves working with an integrated ecosystem of farmers, buyers, and agri-input



providers that are linked not just via digitalised financing flows (e.g., input payments to agri-input providers when the farmer is approved for a loan, digital payments for produce to farmers) but also with improved data insights and non-financial value-added services such as advisory services for farmers, agri-input screening, and market facilitation.

Market Linkage – Agri-Input and Food E-Commerce Services

Agriculture e-commerce services are online retailers of agricultural produce for urban consumers or agricultural inputs for smallholder farmers; they rely on online order fulfilment via either shipping or a combination of online and offline (i.e., brick and mortar store) footprints.

Like digitally-enabled value chain integrator models, agricultural e-commerce services **require a significant amount of value chain investment and intermediation** from the D4Ag enterprise in order to source high-quality product, provide additional value-added activities (e.g., sorting, cold chain services, and packaging for livestock and fresh produce, or quality assurance for agri-inputs), and then manage the payments and the logistics of getting the product to the end-user at the right place and time.

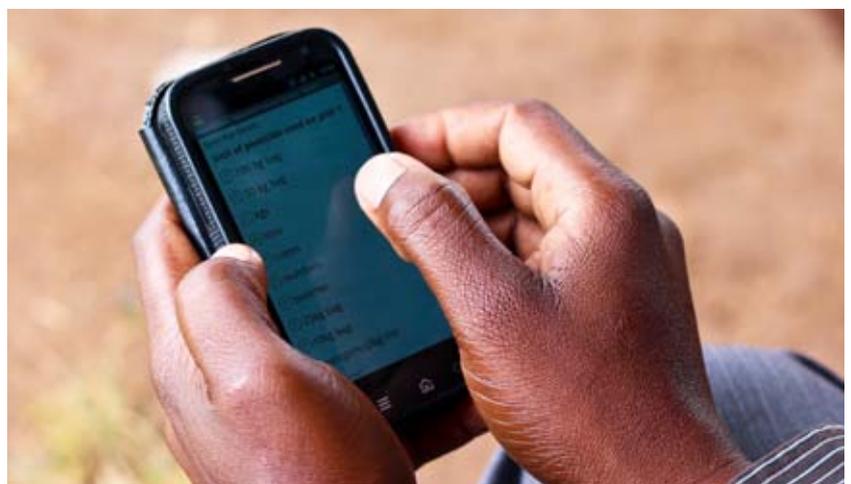
On the plus side, e-commerce models have a **greater potential to bypass intermediaries and can thus theoretically generate more value for both the D4Ag provider and the farmer than other market linkage models**, since such models extend the link directly to the product's end-user as opposed to linking up with intermediary wholesalers or retailers who take their slice of the value. On the negative side, unlike value chain integration models for non-commercial smallholders, digital retail storefronts tend to require wealthier, more sophisticated, and thus smaller customer bases.

For **e-commerce off-take models**

like digital grocers, customers of the e-commerce businesses should ideally have good connectivity, digital payments accounts, a smartphone/tablet/PC to access the online shop, and interest in purchasing (and possibly paying a premium for) fresh, high-quality, locally sourced food. Some workarounds to these constraints exist – such as SMS ordering instead of an online storefront or cash-on-delivery models in the place of digital payments. In effect, however, this model translates into a more niche urban middle-class market for online grocers and thus, by extension, has more limited potential as an e-commerce market linkage model that attempts to formalise smallholder value chains and link them directly to urban consumers. These constraints, and the challenges of some African e-commerce retailers like Jumia in recent years, have led some sceptics to question the scalability of food e-commerce models and their potential for farmer impact in Africa.¹⁰⁹

Even if the market is 'niche', however, this could still be a highly attractive model for D4Ag enterprises as niche does not necessarily meet small. The middle class in Africa is already several hundred million strong, and this middle class is growing quickly with rising GDP and urbanisation.¹¹⁰ By 2030, 47-50% of Africans will live in cities, up significantly from ~40% today, and for every 1% increase in urbanisation there is generally a 5% increase in food sales.¹¹¹ There are thus millions or

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tens of millions of people in the urban areas of most African countries with discretionary income, but few high-quality retail food stores per capita.

With these trends in mind, investment into food e-commerce businesses in Africa that link farmers directly to end-consumers is growing. How precisely these D4Ag players interact with the farmer varies by model, so the impact on farmers is not always clear, but a number of examples are emerging that show that such market linkage models can be viable and attractive to both farmers and e-commerce entrepreneurs.¹¹² Examples of such direct-to-consumer local produce e-commerce enterprises include **IzyShop** in Mozambique, **FarmFresh** in Gambia, **HMart** and **Get It Rwanda** in Rwanda, **Jangolo** in Cameroon, **Premium Hortus** and **Jinukun** in Benin, **Farmart** in Ghana, **Village Market** and **Foodstock Farmers Market** in Nigeria, **Khula** in South Africa and **Herdy Fresh** and **Kitchen Soko** in Kenya.¹¹³

On the input retail side, **agriculture input e-commerce enterprises serving smallholder farmers** also have substantial constraints on market size, including poor rural connectivity, limited farmer digital literacy, and the high costs of rural transport and shipping logistics. In effect, these constraints lead to a parallel situation in which digital-only e-commerce sites are often limited to serving

wealthier farmers or selling inputs for more commercial value chains (e.g., livestock or fisheries products).

At the same time, it is clear that D4Ag entrepreneurs are finding ways of mitigating some of these challenges by using SMS/call centres to handle order-taking from connectivity-constrained farmers, offering free advice on agri-input selection and use to deal with issues of knowledge and trust, and finding local partners capable of facilitating last-mile delivery logistics. The number of such D4Ag enterprises appears to be smaller than that of food e-commerce stores; examples include **Afrimash** in Nigeria, **FarmIT** in Kenya, and **eMsika** in Zambia.¹¹⁴

Market Linkage – Agriculture E-Marketplaces

Agriculture e-marketplaces are D4Ag market linkage solutions that require little or no human intermediation, and that bring individual buyers and sellers together via virtual trading marketplaces.¹¹⁵

Agriculture e-marketplaces provide a platform for various sellers and buyers of agricultural products to transact. For off-take e-marketplaces, sellers can include individual farmers, farmer groups, or cooperatives posting their offers. Buyers range from small agri-

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dealer buyers and aggregators to substantial agri-processors and wholesalers to last-mile food retailers. For the input e-marketplace variant, sellers include various types of input supply chain intermediaries while smallholder farmers typically are the buyers.

E-marketplaces can help solve the problem of inefficient and fragmented agricultural markets when and if they are able to crack the challenges of identifying and attracting enough buyers and sellers. To do so, e-marketplaces need to invest into effective marketing and – more importantly – must embrace innovations that build trust that is often missing in smallholder farmer value chain relationships. The trust-building mechanism can simply be the reputation or brand of the e-marketplace backer (e.g., MasterCard Farmer’s Network), a reliable payments platform with which the marketplace is associated (e.g., Cellulant’s Agrikore), partnerships with credible government agencies or NGOs (e.g., Farm-to-Market Alliance), value-added services such as free advice, explicit insurance or guarantee mechanisms to mitigate the risk of non-performance by counterparties and, lastly,

technology-based innovations like the use of blockchains to build trust via transparent and immutable transaction records (e.g., Cellulant’s Agrikore).

When e-marketplace platforms succeed, whether on the input or off-take market linkage side, they can theoretically unlock substantial value through efficiency gains and other positive knock-on effects. These effects include the ability to use transaction information at scale to deliver value-added advisory or market agri-intelligence services across smallholder value chains – or to convert those transaction data into records that value chain participants can use as a form of collateral for working capital or for smallholder farmer input loans.

The number of e-marketplace D4Ag solutions in Africa is growing – our database is now tracking more than 15 such players. The majority tend to be at very small pilot scales today (<25,000 smallholder farmers registered); a handful, however, are starting to reach much greater scale and aspire to reach millions of farmers across Africa.





Doreen Hove, USAID

Of the various examples of e-marketplaces that aim to link farmers to agricultural produce buyers, **MasterCard's Farmers Network** (formerly known as **2Kuze**) is likely the most ambitious e-marketplace in Africa today. Incubated by MasterCard's Lab for Financial Inclusion in Nairobi, and currently deployed in Kenya, Uganda, and Tanzania, this solution aims to systemically integrate smallholder farmers from loose value chains with quality buyers via a digital transaction marketplace for individual sellers and buyers. Participation in the network involves all actors adopting MasterCard-led payments digitalisation.¹¹⁶

Smaller start-up examples of e-marketplaces that link farmers to buyers include **Usomi's Rubi** and **Mifugotrade** in Kenya, **Farmster** in Tanzania, **Animart**, **Zowasel** in Nigeria, and **eFarm** in Cameroon.¹¹⁷ **TruTrade** in Kenya and **AgroCenta's AgroTrade** in Ghana also likely fall into this category, though they do feature village-level entrepreneur agents as part of their models, and so are not purely digital marketplaces.¹¹⁸ On the input marketplace side, examples of active e-marketplace start-ups include **FarmAll** in Kenya and **Agro Market Day** in Uganda.¹¹⁹

A few marketplace players are focusing on both the input and off-take linkage pathways – **Lima Links** in Zambia and **Farmerline** serve both produce and input marketplaces.¹²⁰ **Cellulant's** new **Agrikore** solution also focuses on both input and produce e-marketplaces via a blockchain-based smart-contracting, payments and marketplace system that seeks to ensure that everyone in agriculture (farmers, FMCGs, agriculture inputs providers, produce aggregators, insurance companies, financial institutions, governments, development partners) can do business with each other in a trusted environment.¹²¹

Across all of these solutions, the interaction between the buyers and sellers can be simply memorialised as a record in the e-marketplace or can incorporate the processing of payments for the transaction on those e-marketplaces that have third-party payment partners or proprietary payment solutions such, for example, **MasterCard's Farmers Network**, **Cellulant's Tingg** payments mechanism in the case of **Cellulant's Agrikore** e-marketplace, or the use of **Agrocenta's AgriPay** for their **Agrotrade** e-marketplace.



Market Linkage – Mechanisation Access

D4Ag mechanisation access solutions use digital tools and channels to link smallholders to farm machinery or farm mechanisation services while disrupting or leapfrogging the affordability, availability, and logistics constraints of traditional smallholder farmer agriculture mechanisation business models.

Farm mechanisation has been the pivot to the agricultural revolution in many parts of the world and has contributed greatly to the increased output of food crops. In the African smallholder context, mechanisation – particularly the greater uptake of irrigation and tractors during the crop production and harvesting cycles, as well as the integration of cold chains and mechanised processing post-harvest – has the potential to dramatically improve yields, generate new, higher-quality employment opportunities and income streams, increase resource-use efficiency, and mitigate climate-related hazards.¹²²

The reality of the mechanisation status quo in Africa is, however, a challenging one. While tractors are used to prepare land on over 60% of cultivated lands in Asia, the corresponding figure for Sub-Saharan Africa is currently around 5%.¹²³ Likewise, only 3.5–5% of the area cultivated in Sub-Saharan Africa is currently equipped for irrigation, by far the lowest of any region globally.¹²⁴ Unsurprisingly, there is a growing consensus on the acute need to prioritise smallholder farming mechanisation in order to achieve Africa’s ambitious agricultural transformation goals. The issue has gained significant momentum in the past year as reflected by the African Union Commission’s launch in 2018 of the Sustainable Agricultural Mechanisation Framework for Africa and the concurrent strong call from the Malabo Montpellier Panel for increased investment in smallholder farmer agricultural mechanisation.¹²⁵

While the topic of barriers to mechanisation is a complex one with many policy and market failure dimensions, it is becoming clear to many sector experts that innovative **D4Ag solutions, in particular, hold the potential to address several of the major constraints to mechanisation uptake.**¹²⁶

Some of the key barriers that D4Ag solutions can address include high capital costs of mechanisation technologies relative to the income levels of most African smallholder farmers, the absence of affordable financing for mechanisation, challenges of supply-demand matching in fragmented value chains with poor information access, the scarcity or absence of distribution infrastructure, and issues of equipment quality assurance and ongoing maintenance in remote rural areas.¹²⁷

Our review of D4Ag market trends and sector interviews suggest that the two most immediately promising D4Ag solution areas in this regard are **shared economy for mechanisation** and **pay-as-you-go (PAYG) mechanisation** solutions. While the number of start-up enterprises focused on either opportunity is still relatively small – perhaps a dozen out of the nearly four hundred D4Ag solutions tracked – it is rising quickly with multiple new entrants in just the past two years, and growing inflows of venture financing.

The first of these opportunity areas is the use of ‘Uber-ised’ shared economy solutions to link farmers to mechanisation providers and services. The most prominent examples of this model in Sub-Saharan Africa are the use of digital shared service solutions to link farmers to tractor services,¹²⁸ though the model is also readily extendable to other mechanisation services that require capital intensive yet mobile agricultural machinery such as high-cost field diagnostic equipment (e.g., soil and crop testing scanners from enterprises like **AgroCares**), land-levelling equipment (e.g., precision laser land-levellers from companies like **Trimble** that are suited to African smallholder settings),¹²⁹ and portable



Siegfried Modola, IFAD



mechanised systems for the variable-rate application of fertilisers, pesticides, and herbicides (e.g., fertiliser sprayers).

The best-established example today is Lagos-based **Hello Tractor** which now has operations across multiple Sub-Saharan African countries and is picking up investors, as well as technology and distribution partners like **IBM** and **John Deere International**.¹³⁰ Other African start-ups with shared economy mechanised equipment rental models include **TroTro Tractor** in Ghana, **E-Tinga** and **FarmAll** in Kenya, and **Kobiri** in Guinea.¹³¹ Another notable arrival in Africa is **Mahindra & Mahindra's Trringo** solution, which recently launched operations in Tanzania. Trringo already has several years of track record in five Indian states with 1.5 million farmers registered for mechanisation services to date – a clear indicator of the potential for the scalability of such solutions in Africa.¹³²

PAYG agricultural machinery distribution is another highly promising D4Ag mechanisation model that takes advantage of digital payment ecosystems and IoT technology to allow farmers to pay for mechanisation equipment in small increments while they use it on their farms.

As in the case of shared economy enterprises, the potential for PAYG models for mechanisation is far broader than the current implementation of such solutions in Africa, which today tends to focus on deployments of solar powered irrigation equipment. These solutions have grown out of a broader solar off-grid energy PAYG sector that historically focused on household lighting and home entertainment (i.e., TV) products, and features such players as **M-KOPA**, **Zola Electric**, **Fenix International**, **BBOX**, and **PEG**.¹³³ PAYG solutions reached roughly 2 million Sub-Saharan African households across two dozen countries by early 2018,¹³⁴ and – based on conservative growth rate estimates – are today likely used by more than 3 million

households in the region. A large share (60–80%) of the clients of these off-grid solar PAYG companies are either smallholder farmers or peri-urban and rural Africans who have at least partial revenue streams from agriculture.

Within this broader PAYG space, **SunCulture** in Kenya is the best-established player at the agriculture-energy nexus of PAYG agricultural equipment services. The company currently focuses on deploying a PAYG solar irrigation pump, but also delivers value-added advisory services to its client farmers (i.e., weather advisories and tailored advice on when and how much to irrigate) and has a vision of ultimately integrating many other types of agricultural equipment into its platform such as post-harvest processing equipment and as cold storage equipment for dairy and horticulture.¹³⁵

Other examples of PAYG agriculture equipment players in Africa include **Azuri's GrowFast** and **Simusolar** for solar irrigation, **AgSol** for PAYG processing and milling, and **ColdHubs** for PAYG cold chains.¹³⁶ At least a half-dozen new Africa PAYG entrants are expected across these different models in the next 6–18 months, so this segment of the market warrants close monitoring for those D4Ag investors interested in the agriculture-energy nexus.¹³⁷

Supply Chain Management Use Case

Supply chain management solutions are primarily designed for and marketed to agribusiness to make it more convenient, safe, efficient, and profitable for agribusiness to interact with smallholder farmers. The primary focus of solutions in this use case is to help agribusinesses manage their relationships with those smallholder farmers who are already linked to them via formal off-take or less formal input purchasing relationships – or to help them integrate new farmers into their value chains. Using supply chain management



SUPPLY CHAIN MANAGEMENT

Figure 8 Supply chain management – overview of sub-use cases and solution examples



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solutions need not mean becoming a paying client of a third-party D4Ag provider. It can also include allocating resources to build and deploy digital tools in-house.

We define 'agribusiness' broadly for the purpose of this use case. On the off-take market side, agribusiness users of supply chain management solutions can range from large, global Africa-focused buyers and processors – such as ETG, Olam, Mars, Cargill and Barry Callebaut – to national and regional African agro-processors – such as the Dangote Group in Nigeria and NWK Agri-Services in Zambia – to various types of smaller downstream farmer aggregators with outgrower schemes, such as smallholder cooperatives and nucleus farms. On the agri-input side of the value chain, business users of supply chain management solutions range from global or regional agri-input players, such as Syngenta, Yara and OCP, to small and mid-sized national agri-input companies to other more downstream input value chain intermediaries such as input wholesalers and agro-dealers.

The business and impact case for supply chain management solutions is growing.

In many cases, based on self-reported impact data, D4Ag supply chain management solutions are already increasing transparency, efficiency, and operational profitability, particularly for well-established tight (i.e., commercial and structured) smallholder value chains such as tea, cocoa, coffee, high-value

horticulture, and cotton.¹³⁸ For other supply chain management solutions, the evidence is still at an early stage but is already sufficiently compelling for agribusinesses to invest in integrating these kinds of tools into their work at significant scale. While this is not evidence of impact, per se, the growing interest and investment in supply chain management on the part of agribusiness attests to its value.¹³⁹

The specific benefits of supply chain management solutions depend on the client type. Off-take agribusiness actors are the primary 'client' and 'user' of most supply chain management D4Ag solutions. For such players, the theoretical benefits of these solutions include lower transaction costs of attracting and maintaining smallholder farmer relationships, significant cost-efficiencies for many other types of operations (e.g., agent field force management, sustainability certification, transport logistics), improved transparency into and traceability of value chain data, greater accountability of contracted farmers and agribusiness field agents, better quality of product sourced, reduced post-harvest loss and waste and, ultimately, greater profitability and scale. Input agribusinesses also use some forms of supply chain management solutions to establish more direct relationships with their smallholder clients and to better monitor and manage the performance and quality of (typically independent and highly fragmented) agri-input value chain intermediaries.



For input agribusinesses who utilise supply chain management solutions, benefits should also ultimately translate into improved profitability due to cost-savings per farmer reached and reduced input counterfeiting, as well as stronger and more direct relationships with smallholder farmers and other intermediaries that promote input demand and thus revenue growth.

At the individual farmer level, while smallholders are not the direct clients of supply chain management solutions, they are often beneficiaries of activities that better integrate them into formal value chains and should therefore see the eventual benefits of higher yields and incomes through value chain integration.

Supply Chain Management – Traceability and Certification Solutions

Traceability and certification solutions help agribusinesses onboard farmers, document farm compliance with standards, and trace produce across value chains with higher fidelity and lower costs.

The demand for traceable and certified agricultural products is on the rise in global markets as international consumers demand more transparency and accountability in supply chains.¹⁴⁰

The growing popularity of concepts such as ‘farm-to-fork’ and increased focus on compliance with environmental and social commitment standards and codes of conduct (e.g., regarding labour practices, human rights, and issues such as deforestation and water use) highlights the importance of full visibility into food chains for consumers as well as producers. To comply with an increasing number of both mandatory and voluntary standards and certification schemes, agribusinesses that procure crops from African farmers are increasingly adopting **traceability and**

certification solutions. These solutions, also known as ‘tracking and traceability’ or ‘track and trace’, are digitally-enabled tools that link data about specific farms and farmers to a view of how food commodities flow through value chains.

These tools enable agribusinesses to have full visibility into the agricultural last mile, maintain a digital record of farmers and other downstream supplier intermediaries, and facilitate auditing for certification requirements, which can become hugely time consuming and expensive in the absence of a strong digital data trail. The focus on certification explains why, historically, most digital traceability solutions on the African market have focused on smallholder products for export markets.¹⁴¹

African domestic agribusinesses have had less of demand for such tools due to fewer standards, low enforcement, or low consumer demand for certified products, but this is now starting to change¹⁴² due to a rising middle class in some African countries and, more importantly, growing recognition by the African agribusiness community that traceability tools can create broader value – for example, by helping agribusiness better manage instances of food-borne illness and food recalls by making it

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possible to trace the issue to the source and target costly recalls only to impacted supply chain actors.¹⁴³

While agribusiness is the ultimate beneficiary of such tools, smallholders also benefit because these tools help them access new markets with higher prices and, on the input side of the value chain, to protect themselves from inferior agricultural inputs.

Traceability solution providers active in Africa fall into a few different categories including specialist traceability software vendors, big tech firms, certification organisations, and government platforms. Specialised traceability start-ups typically have deep expertise in the technical elements of track-and-trace solution development as well as the ability to navigate issues of interoperability that are increasingly relevant given the proliferating number of food and environmental certification regimes. Examples include solutions such as **SourceTrace**, **SourceMap**, **EProd**, and **FarmForce**.¹⁴⁴

The growing market for traceability solutions has also attracted big technology sector actors such as **SAP**, which launched its **Rural**

Sourcing Management platform two years ago and now works with large global buyers and processors such as Barry Callebaut, reaching over 225,000 farmers across Africa.¹⁴⁵

Another large new digital traceability and certification platform is managed directly by a certification standards body, the **Rainforest Alliance Marketplace 2.0**, which builds on **ChainPoint** software's traceability product, and has broad track-and-trace functionality in support of the Rainforest Alliance's mission.¹⁴⁶

Finally, in some African countries there are also examples of national, government-run track-and-trace solutions. The **Namibian Livestock Traceability System (NamLITS)**, which has already proven its worth during recent foot and mouth disease outbreaks in the country, is one notable example.¹⁴⁷

Supply Chain Management – Input Quality Assurance and Anti-Counterfeiting

Input quality assurance and anti-counterfeiting D4Ag solutions help agribusinesses ensure the

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integrity of their brands and help farmers validate the authenticity and quality of received inputs.

A major barrier to agricultural technology adoption in Sub-Saharan Africa is the low quality of many agricultural inputs, coupled with a lack of reliable information on input quality.¹⁴⁸

Counterfeit products range from benign fake or adulterated materials to banned substances that are harmful to crops and human health. Beyond counterfeit products, the market for inputs such as seeds, fertilisers, and pesticides/herbicides in Africa is also rife with substandard products that do not effectively perform as they should, have substandard concentrations, or are simply expired.¹⁴⁹

The ubiquity of substandard inputs directly reduces farmer productivity and, together with the perception of widespread counterfeiting, reduces demand for high-quality inputs. This lowers input prices and reduces profits for producers of genuine products, causing a form of adverse selection in which counterfeit products push high-quality genuine products out of the market.¹⁵⁰

While some of the traceability solutions described in the last section (e.g., **SourceTrace**) can be applied fruitfully to input distribution to trace potential sources of fraud, counterfeiting, and mislabeling in input value chains, there are also more specialised D4Ag solutions that are starting to tackle the issue.

One example of such solutions is **QualiTrace**, a Ghanaian startup with Africa-wide ambitions which uses track-and-trace technology to authenticate farm inputs and fight counterfeiting. QualiTrace not only authenticates but also provides analytics tools to trace products as they move from one step to another until the final consumer also independently verifies the source and quality of the product.¹⁵¹ Other interesting examples of enterprises focused on agriculture input authentication are **mPedigree** and **Sproxil**, which have multiple digitally-enabled quality assurance solutions for input brand owners, consumers, and governments, including SMS or IVR unique identifier code verification approaches and optical coding (e.g., 2D barcodes) that can be scanned by phone cameras.¹⁵²

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Supply Chain Management – Logistics

Digital logistics platforms are tools that support the surveillance and operational improvement of physical storage and transport infrastructure and, in particular, the transport of agricultural products across the full span of the value chain from producers to markets.

In the D4Ag context, logistics platforms can make complex, disaggregated value chains more efficient and precise, a useful value proposition given the massive inefficiencies, physical infrastructure gaps (e.g., in terms of the quality and availability of roads, vehicles and storage warehouses) and corruption, theft and red tape that characterise the last-mile transport of agricultural commodities and finished products into and out of rural areas (and, similarly, the export/import of agricultural products over longer distances).

The use of digital solutions to address logistics challenges is a much broader topic than D4Ag.¹⁵³ Most pertinent for the purposes of this report are players like **iProcure**, **Logistimo**, **Virtual City**, and **WeightCapture**, which specialise in

agriculture value chain logistics tracking, analytics, and optimisation through their apps for agribusinesses and farmers.¹⁵⁴ **iProcure**, for example, combines digital logistics surveillance, analytics, and supply chain management tools with a physical network of agri-input agents and warehouses that help agribusiness aggregate and optimise smallholder input supply chains.¹⁵⁵

Virtual City and **WeightCapture**

combine technologies for temper-proof digital weighing of produce with software that monitors the progress of agricultural products across value chains with digital tracking at key hand-off points. Several of the integrated supply chain ERP solutions mentioned also have logistics components in their systems – for instance, a product transfer logistics tracking application that is a part of **SourceTrace**'s solution architecture.

As in the case of D4Ag Input Quality Assurance tools covered above, the digital logistics solution sub-type serves a relatively small niche, but still has significant promise for solving the operational challenges of the African agriculture sector as part of a broader portfolio of complimentary digital solutions.¹⁵⁶



Supply Chain Management – Supply Chain ERP platforms

Supply chain ERP platforms offer a fully integrated package of digital services to agribusiness that duplicates some elements of the solutions covered above, but goes well beyond this to include operational analytics, value chain intelligence, and tools for managing smallholder farmers and agent field forces.

The types of data that need to be captured for traceability, logistics, and quality assurance uses are often identical to information needed by agribusinesses to monitor key performance indicators (KPIs), optimise operational performance, and glean insights into farmer and agent field force behaviour. While there is some resulting overlap between supply chain ERP solutions and those covered in the sections above, ERP solutions are a largely distinct D4Ag segment both in terms of functionality and the kinds of vendors that are involved.

Technically speaking, agricultural ERP platforms are solutions that integrate all core processes needed to run an agribusiness (e.g., finance, HR, manufacturing, supply chain, services, procurement, and others) into a single system.¹⁵⁷ We use the term ERP more loosely to indicate digital solutions that support farmer and field force management tools for smallholder value chains, typically integrated with traceability, logistics management, quality assurance, and business intelligence elements.

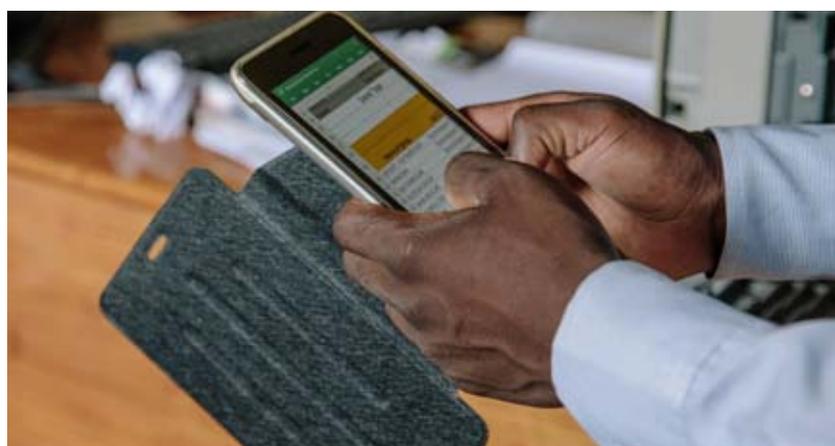
The overall value proposition of D4Ag supply chain solutions is to improve the effectiveness and cost-efficiency of smallholder-centred African agribusinesses at every level of operating scale. For the largest agribusinesses (i.e., global buyers/processors or global input providers), these tools are a way to reduce the costs of interfacing

directly (and effectively) with smallholder farmers while also improving intelligence on and control over all aspects of value chain activities. For small and medium-sized agribusiness, these types of tools are a means of transforming companies with paper-driven processes into more mature and professional data-driven agri-enterprises that have the information and management bandwidth to grow in a more intentional fashion.

For smaller and more downstream value chain intermediaries like cooperatives and agro-dealer networks, these tools focus on enhancing capacity and improving accountability. Finally, for farmers, well-executed supply chain ERP solutions should make the process of accessing formal value chains more painless due to more streamlined and less time-consuming data capture; more available, knowledgeable and accountable field force agents; and access to value-added tools that can be bundled with such platforms – e.g., free, high-quality and highly localised advisory services delivered by agents via the supply chain ERP applications.

The number of supply chain management ERP solutions and providers is growing. Examples of interesting solutions in this category within the African D4Ag start-up ecosystem include **Farmforce**, **EProd**, and **Metajua**.¹⁵⁸ These enterprises tend to focus on small to medium-sized African agribusinesses, typically with a range of 1,000 to 20,000 smallholder farmers being managed per each agribusiness ‘account’

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or 'license'. Others like TaroWorks focus on agriculture sector NGOs.¹⁵⁹ **AgriGo** focuses on even smaller players like farm cooperatives.

A few supply chain ERP start-ups from other geographies – such as **CropIn**, **SourceTrace** and **Annona** – have also brought their solutions to the African market.¹⁶⁰ Some of these, including **CropIn** and **SourceTrace**, aspire to serve large-scale agribusinesses and already have extensive experience in working with big national or international buyers in India.

Big tech enterprises in the supply chain ERP segment that focus on smallholder farmers, such as **SAP's Rural Sourcing Platform** and **Accenture's Connected Crop Solution (ACCS)**, focus on serving the needs of medium-sized and large agribusinesses. **SAP's** solution, for example, focuses on global and regional sourcing organisation. **ACCS**, on the other hand, focuses on medium-to-large agri-input organisations and aims to connect the three key stakeholders in that value chain – the field agent, the agri-input company, and the farmer.¹⁶¹ Another relevant technology initiative is the **Connected Farmer** solution from **Vodafone**, developed by Vodafone's Mezzanine team and focused on smallholder value chain SMEs and medium-sized agribusiness to allow such players to effectively and cost-efficiently enrol and manage the smallholders they work with.¹⁶²

A few large agribusinesses focused on Africa have developed their

own in-house agriculture value chain digitalisation tools to support smallholder farmer registration, communications, data collection, supply chain management/logistics, traceability, and business intelligence needs. The most widely discussed of these types of platforms for Africa is the **Olam Farmer Information System (OFIS)**, which Olam uses to manage more than 250,000 farmers across its countries of operation today (both in Africa and Indonesia) – with a target of 500,000 farmers globally by 2020.¹⁶³ In addition to serving the immediate internal needs of Olam from the perspective of farmer certification and traceability, the platform is also a tool for Olam's country-level intermediaries (e.g., farmer groups, cooperatives) and field force agents to manage their own organisations, counterparties, and finances.

While less known in the public domain, several other large buyers and processors active in Africa have also invested heavily in their own in-house digital supply chain management and track-and-trace solutions that have comparable features, but are not always integrated into one supply chain management platform.

Financial Access Use Case

D4Ag financial access solutions facilitate farmer access to payments, savings, credit, and insurance, or – less directly – provide data analytics and digitalisation support to financial service providers that can then serve smallholder farmers at broader scale and lower cost.

By any global measure, African farmers, especially smallholders operating on plot sizes of two hectares or less, face chronic challenges of limited access to financial services – including savings, credit, and insurance.¹⁶⁴ From the perspective of smallholder farmers, the overarching objective of financial access D4Ag solutions is to provide a link to high-quality and affordable financial products and services that create an array of new

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FINANCIAL ACCESS

Figure 9 Financial access – overview of sub-use cases and solution examples



opportunities – among them, the ability to transact at much lower cost with input providers and purchasers of their products, purchase the inputs they need to increase their productivity and incomes and significantly reduce their risks from weather, pests, plant diseases, cross-border market disruptions and a myriad other factors that make smallholder farming in Sub-Saharan Africa such a financially precarious livelihood.

Issues of smallholder farmer financial access are incredibly complex and the ecosystem around this topic is rapidly evolving given the rapid transformation in underlying data analytics and payments technologies, financial services business models, and resulting financial products.

There are also a number of technical expert organisations, like IFC/CGAP, the MasterCard Foundation’s Rural Agriculture Finance Learning Lab (RAFL), the Initiative for Smallholder Finance (ISF), and NGOs like Mercy Corps (via its Mercy Corps AgriFin Accelerate programme) and AGRA that are all investing in advancing the knowledge frontier on the market trends, business models, and impacts of smallholder-farmer-focused digital financial services through regular research publications – such as the forthcoming 2019

update to the sector-shaping smallholder finance ‘Inflection Point’ reports produced by a consortium of leading experts on the subject.

Considering the available work of these parallel knowledge initiatives, our primary intent in the following sections is to provide an overview of key financial access solution segments with some illustrations, rather than diving more deeply into financial services trends and economics.

D4Ag financial access solutions need not achieve their positive impact on smallholder farmers directly to qualify for this discussion.

Some of the D4Ag solutions covered in this section are, indeed, themselves financial service providers (FSPs) that use digital channels and other types of digital tools to deliver new types of digital payments, savings, credit, or insurance products to the farmers they serve. This includes both new fintech entrants as well as some more traditional banks and MFIs that have integrated digital technology into the way they serve farmers and have launched new digital business units or products.¹⁶⁵

Many of the D4Ag solutions that we cover under this use case, however, function

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indirectly. Such solutions are B2B service providers that benefit farmers by working with local financial institutions of varying types and scales. The value proposition of such D4Ag enterprises to financial institutions can encompass a few different drivers of digitalisation value-addition including (i) helping FSPs identify and connect with smallholder farmers they would not otherwise be able to find (or be able to find profitably); (ii) reducing the operational costs for FSPs of working with smallholder farmers (e.g., lowering costs of risk assessments, payment transactions, credit collection processes, insurance claims processing, etc.), and, most critically; (iii) de-risking farmers so that they can become 'bankable', i.e., so they can be served at the very least profitably and ideally with sufficiently attractive economics to justify pursuing smallholder farmers clients (and related financial products) versus other alternatives.¹⁶⁶

This report identifies six important sub-types of D4Ag financial access solutions: (i) payments; (ii) savings; (iii) credit; (iv) insurance; (v) crowd financing (crowd farming); and a B2B solution area of (vi) financial analytics and process digitalisation for financial service providers (see Figure 9).

Financial Access – Payments

Payments allow smallholder farmers, input providers, buyers and others to exchange money with each other without cash. Mobile payments significantly lower transaction costs and increase efficiency as money can be transferred electronically. Money leaves and enters bank accounts with less lag time, with little risk of being lost or stolen, and regulatory constraints on the amount of cash one can carry become irrelevant. For these reasons, the ability to conduct mobile payments is a baseline enabler for many other types of smallholder farmer financing solutions. Sub-Saharan Africa, notably, is the only region in which more than 20% of adults have a mobile money account; over the past five years, the share of adults with such an account has risen roughly twice as fast as that of adults with a traditional, formal bank account.¹⁶⁷

The D4Ag payment solutions this report is concerned with are derivative payment services rather than general digital payments solutions like M-Pesa; the services in question are tailored to smallholder farmers' needs and solve for very specific challenges in African smallholder farmer value chains.



Marco Salustro, IFAD



The most acute challenge from a payments perspective is that cash is still king for most transactions, agricultural or otherwise.¹⁶⁸ Despite digital payment systems that are growing quickly – and now becoming ubiquitous in some African countries, such as Kenya – the average African smallholder lives in remote areas where mobile network coverage can be weak or non-existent and, most critically, mobile money cannot yet be used to purchase goods and services from local merchants.

Smallholder farmers are therefore hesitant to accept digital payments from buyers; when such payments do come in a digital form (e.g., from government rural livelihood or agriculture sector subsidy schemes), the experience of most African subsidy direct transfer programmes – such as Cellulant’s e-wallet in Nigeria – suggests that farmers prefer to cash out immediately.¹⁶⁹ The big near-term opportunity for smallholder farmer payments in the coming few years is therefore to drive broader agriculture value chain payment digitalisation via business-to-person (B2P) and government-to-person (G2P) payment schemes involving farmers, as well as efforts to create meaningful agricultural (and non-agricultural) product and service choices for farmers where digital payments are accepted, so that the value proposition of digital payments increases.¹⁷⁰

Such agriculture value chain digitalisation initiatives, driven directly by MNOs or by traditional FSPs and fintechs leveraging MNO digital payments infrastructure, are currently an intensive focus for many sector experts and intermediaries like the **Better Than Cash Alliance** and the **GSMA’s mAgri team**.¹⁷¹

There are a number of D4Ag players that are trying to support farmer payments digitalisation and the development of broader agriculture digital payments ecosystems.

One model involves supporting G2P payments (typically various types of direct transfer rural livelihoods or agriculture sector subsidy schemes) for farmers via innovative e-wallet models that tie subsidy transfers to agricultural input payments, while at the same time trying to add sufficient value to the e-wallet account to build farmer familiarity with and use of digital payments for a wider variety of goods and services. Ultimately, the e-wallet can serve as a stepping stone to other digital financial products like commitment savings, input credit, and agricultural insurance. The largest-scale example of this model was **Cellulant’s** work earlier this decade with the Nigerian government’s Growth Enhancement Support (GES) Scheme.¹⁷² Other innovative

M-Pesa



examples include **Zoona**'s e-voucher model for agriculture¹⁷³ and, most recently, the **Smart Nkunganire System** in Rwanda, which is helping to drive agriculture payment digitisation at a national scale.¹⁷⁴

In the B2P payments space, innovative models worth highlighting include **SmartMoney** in Tanzania and Uganda and **AgroPay** in Ghana. Both models combine the digitalisation of agriculture value chain payments with efforts to create broader village-level digital payments and digital payments acceptance ecosystems. **SmartMoney**, for instance, currently serves more than 200,000 rural people and over 2,000 merchants, and follows the model of establishing 'E-Villages' – village-wide, ledger-based digital money ecosystems that are supported by digitalised payments from agricultural off-takers, on the one hand, and, on the other, by activities to promote digital payment uptake for agri-input providers and a wide range of other small, rural businesses and merchants.¹⁷⁵

Financial Access – Savings

The use of savings products can make a big difference in the lives of poor farmers. Smallholder farmers typically get much of their income in a few big lump-sum payments each year during harvest times and then need to pay down debts, save money for day-to-day expenses between seasons, and lay funds aside for next year's seed, fertiliser, and other productivity-enhancing farming inputs.¹⁷⁶ Savings are thus needed to ensure expenditure smoothing across variable seasonal income patterns, to make farm investments, and to build household resilience in the face of agriculture-related shocks (e.g., pest/disease infestations) or personal financial crises (e.g., unanticipated health expenditures). When smallholder farmers use savings accounts, this can make a major difference in the amounts they save and invest in their farms, which directly translates into increased farming profits, improved long-term incomes and higher levels of consumption.¹⁷⁷

Saving money is, however, very challenging for smallholder farmers. The first obvious issue is access to appropriate, affordable, and accessible savings products. According to the most recent regional data, only 19% of Sub-Saharan African adults saved semi-formally via channels like village savings and loan associations (VSLAs), and just 9% saved formally through bank, MFI, or savings and credit cooperative organisation (SACCO) savings accounts.¹⁷⁸ The second challenge is that when farmers do have savings accounts, usage is often low. Saving is hard for everyone; it is especially so for poor smallholder farmers with volatile incomes and urgent expenses.

Digital savings for farmers is an important area of innovation for solutions that are starting to address both access and savings behaviour challenges.

Digital technologies are addressing the challenge of smallholder farmers' access to savings via **electronic wallet products that have savings features**, either directly when offered by formal financial institutions, or in partnerships between payments players who already have extensive rural reach and deposit-taking financial institutions with banking licenses. The primary feature of such digital savings models is that payments and e-wallets are used as an entry point for extending savings account access to large numbers of smallholder farmers.

We touched on one variant of this model above with national scale e-wallets tied to subsidy schemes, such as Zoona in Zambia and the IFIKO universal wallet integrated into the Smart Nkunganire System (SNS) in Rwanda.¹⁷⁹ **Zoona** partnered with **FINCA Zambia** in late 2018 and now allows farmers with Zoona e-wallet accounts to earn a 10% interest on their savings.¹⁸⁰ Similarly, farmers registered with **SNS** in Rwanda will be able to get access to savings accounts through the Bank of Kigali. Other models in this space involve MNO partnerships such as Safaricom's partnership



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with CBA on the **M-Shwari** savings product in Kenya and Econet's partnership with Steward Bank on the digital **EcoSave** product in Zimbabwe. Not all of these products target smallholder farmers exclusively, the smallholder farmers tend to be major beneficiaries.

To address the behavioural challenge – getting smallholder farmers with access to savings accounts to actually save – D4Ag players are experimenting with different types of digital commitment savings accounts.

One D4Ag solution that has extended the e-wallet model in interesting ways for commitment savings is **Agri-Wallet** in Kenya, a recent start-up that has developed a free digital wallet for the agricultural sector as a business account for farmers, which they can use to save, buy, and earn. When farmers earn revenue through sales, they can choose to be paid in money through M-Pesa or in tokens for their wallet that are earmarked for purchasing input supplies from vetted merchants and drive beneficial savings behaviour.¹⁸¹

Another example of the digitalised commitment savings model is **myAgro** in Mali, which helps smallholder farmers in West Africa pay on layaway (i.e., via piecemeal instalments) for fertiliser, seed and training packages using their mobile phone. Registered farmers can save easily by continuously 'topping up' their **myAgro** account in flexible amounts (€0.90–44.90). The **myAgro** mobile layaway model makes saving for input purchases easy, drives input adoption via the commitment savings model, and, as a result, appears to generate substantial positive impact for farmers' yields and incomes.¹⁸²

Innovative D4Ag savings products are also being developed addressing the needs not only of farmers as individual customers, but also targeting informal farmer savings groups. Organisations like **Care International** and the **Aga Khan Foundation** have been working for years on the formalisation and scale-up of informal savings groups like VSLAs and rotating savings

and credit association (ROSCAs). In the past 2–3 years, these organisations have started experimenting with digital or digitally-enabled savings group models in order to reduce costs of group formation and support and to allow savings group members to access the broader benefits of payment digitalisation. Since 2016, The Aga Khan Foundation, for example, has supported the aggressive rollout of digital savings groups (DSGs), managed via the Foundation's **DSG Platform**, a shared software service implemented with both USSD and application interfaces that fully digitalises savings group management.¹⁸³ Another interesting example from the D4Ag startup space is **Akobaxi** in Uganda, which digitalises village savings groups via a system that includes an electronic 'box' (a customised, connected point-of-sale device), Akobaxi's cloud-based software that runs on this device for managing and monitoring savings group operations and transactions, electronic ID cards readable by the device for individual savings group members, and SMS-based communication to savings group members for transaction records.¹⁸⁴

Financial Access – Credit

In recent years, D4Ag solutions have been a major source of experimental pathways toward confronting the approximately €25–30 billion financing gap facing African smallholder farmers.¹⁸⁵ Given the relatively small size of smallholder transactions, the physical and logistical difficulties of serving clients in remote rural areas, the complexity of agricultural risks (e.g., agroclimatic, commodity prices), and other unusual features of agriculture finance stemming from its seasonal nature, most formal financial institutions perceive lending to farmers as too risky or, at the very least, insufficiently profitable. In Sub-Saharan Africa, for instance, only 95 of 900 banks surveyed provide financing to smallholder farmers.¹⁸⁶

To address the challenge, multiple digital lending products specifically



Akobaxi



designed for farmers have been launched in recent years and, more broadly, many lenders are digitalising elements of their operations. Digitalisation can come in different flavours in the context of smallholder lending. Some FSPs – including both incumbents and new fintech entrants – are deploying digitally branded credit products that involve little or no in-person farmer engagement, rely on digital communications for client acquisition and servicing, and use digital payments for loan disbursement and payment collections. Other FSPs are starting to integrate digital tools, such as digitally-enabled automated credit scoring, but continue to use a blend of digital and human channels for smallholder financing operations.

For financial institutions, the primary motivation for pursuing digitalisation is to reduce customer risk and to lower cost to serve (e.g., no need for loan officers to travel to the field with paper applications or branch-based loan disbursement and repayment processes), both of which should ultimately translate into higher profitability and much broader reach that includes otherwise un-bankable clients. The evidence base for the impact of digitalisation on financial service provider economics is still at a very early stage, but the indications are positive, and the pace of digital initiatives and products is picking up.¹⁸⁷

One pathway for these approaches involves more traditional financial institutions that are digitalising their products and interaction models. Examples include the **KCB's MobiGrow** product in Kenya, **Advans's** digital cocoa-farmer credit product in Côte d'Ivoire, and **Opportunity International's** digitally-enabled loans in Ghana.¹⁸⁸

From fintech innovators, important examples worth monitoring include the digital **Kilimo Booster** farmer credit product from **Musoni** in Kenya,¹⁸⁹ the digital agriculture credit model of **Akellobanker** in Uganda,¹⁹⁰ **Tulaa's** digital credit offering in Kenya, which is integrated into a digital end-to-end market linkage model,¹⁹¹ and digital loans from **Apollo Agriculture**, also in Kenya, which are bundled with a digital advisory product. Many of these players rely on digitally-enabled credit scoring algorithms.¹⁹²

As noted in a recent review by the IFC, while the number of digital lending products is growing, it is at this stage premature to assess the extent to which these models are commercially viable and at what scale. The authors of this report are nonetheless optimistic about a number of these models based on the emerging evidence of both smallholder impact and tangible business model benefits from digitalisation.¹⁹³ At the same time, it is also



Thomas Mukoya, Reuters



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important to recognize that while digital smallholder farmer credit models address some of the systemic challenges of traditional farmer finance, they can also introduce their own risks. These could include the risk of over-indebtedness due to the relative ease of accessing credit digitally, consumer protection concerns about smallholder farmer clients not understanding the products they sign up for (in the absence of human loan agent interaction) and data privacy worries given the large amounts of farmer data (and external data focused on the farm, e.g., from satellites) that are collected and mined by digital credit solutions.¹⁹⁴

Financial Access – Crowdfunding

Another response to the smallholder farmer credit challenge, albeit with a very distinct business model, ‘crowdfunding’ solutions use digital platforms to link farmers who need capital with sponsors who wish to invest.¹⁹⁵ Crowdfunding entails sourcing funds from multiple individuals to invest in a smallholder farmer or other small-scale agricultural enterprises. In some cases, investors, often labelled as ‘subscribers’, receive returns in the form of agricultural produce, but typically the returns are financial usually

ranging from 10–30% over 3–12-month periods and are divided among participating subscribers and the crowdfunding enterprise after the harvest season.¹⁹⁶ When bigger investments are in question, many sponsors can support a farmer together – for example, by ‘sharing a cow’.¹⁹⁷

Facilitated by digital platforms, African smallholder farmer crowdfunding solutions play a bridging role between individual providers and recipients of farm financing.

Firms on the finance supply side of the model focus on aggressively marketing farm investment opportunities via digital channels to attract potential farm investors/financiers from international and diaspora communities or African urban middle class investors. From a demand-generation perspective, these firms recruit smallholder farmers to join their platform and work with them to attractively package the investment opportunity to finance suppliers, often with the addition of a variety of other value-added services such as digitally-facilitated off-take or input market linkages, advisory services, and complimentary agricultural insurance.

The contractual agreement between the crowdfunding platforms and farm subscribers provides details on the returns on investment per farm enterprise, length of





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the production/investment cycle, insurance coverage on funds invested, and secure online payments.¹⁹⁸ Farm ‘subscribers’ also typically receive regular information on the farm’s progress through email alerts and notification of final payments at the end of the production cycle.¹⁹⁹

Our research suggests that there are ~30 crowdfarming enterprises in Africa today, with 80% of these businesses appearing in the past 1-2 years in the wake of **Farmcrowdy’s** success in Nigeria.²⁰⁰ Other prominent examples of crowdfarming businesses include **Growisel** and **Thrive Agric** in Nigeria, **Livestock Wealth** in South Africa, and **Bayseddo** in Senegal.²⁰¹

It is too early to assess the success of crowdfarming models and hard to generalise about the category in terms of farmer value-add given the wide diversity of underlying business models. Many of the D4Ag enterprises are serious, legitimate businesses with thoughtful business models, often melding elements of digitally-enabled advisory services and digital market linkages support for farmer clients with a crowdsourced financing engine. Other solutions in this segment are much more questionable. The minimum viable product version of crowdfunding platforms – a website

for marketing farm investment opportunities and a starting supply of farmers and investors – requires minimal investment. Several of the experts consulted for this report have highlighted that this low barrier to entry (and relative opacity of the actual value-add that some of these platforms deliver to their farmer after the initial farm selection) likely means that some of the copycat models that have emerged recently do not have much substance behind them. They may even present risks to investors. We do believe that the more established and vetted crowdfarming players have as much promise as the highly integrated D4Ag market linkage models that also bundle credit from more conventional sources.

Financial Access – Insurance

Agricultural insurance offers a valuable tool to help smallholder farmers avoid devastating financial losses and limit downside risk associated with investing in their own productive capacity.²⁰²

Without insurance, farmers are highly vulnerable to external shocks given their exposure to environmental hazards (e.g., pests and diseases, weather events), the vagaries of global and regional agricultural commodities markets, and the growing unpredictability across all of these factors brought on by



climate change. Smallholder farmer surveys consistently show that such risks, particularly climate-related risks, are already impacting farmers, often producing disastrous losses. Anywhere between one-fifth and two-thirds of smallholders across a wide range of African countries report an instance of major crop loss over a five-year time period due to catastrophic weather events (e.g., floods, droughts) or due to factors such as pests and disease (which are likewise linked to climate change).²⁰³

Insurance helps mitigate such risks and unlocks opportunity. For example, a recent survey of the literature highlighted that, “with insurance for agricultural livelihoods, smallholders invest more in their farms, education and health; whereas, without insurance, farmers adopt lower risk-and-return farming practices, eschewing investments into more productive practices or technologies.”²⁰⁴ Rates of access to agricultural insurance for smallholder farmers are at extremely low levels, however, with only an estimated 20% of smallholders globally and **only 3-6% in Sub-Saharan Africa using such products.**²⁰⁵

As with other financial access products, the reasons for low uptake are multiple. On the demand side, smallholder farmers generally have low levels of understanding of and trust in complex financial products and, in particular, are highly skeptical of insurance

products of any time. This skepticism is not entirely unfounded as the costs of insurance products can be high and pay-out mechanisms can be slow and cumbersome – or divorced from the reality of the loss-making event as perceived by the farmer.²⁰⁶ On the supply side, smallholder agricultural insurance is a complex product to design. Most importantly, the costs of delivering insurance to often unwilling and remote smallholder farmer customers can severely constrain the profitability and attractiveness of such products to conventional insurers.

Digital technology is starting to break down the barriers that prevent insurance providers from serving the agricultural sector in general and smallholder farmers in particular. By aggregating new sources of data and methods of analysis, D4Ag insurance solutions allow providers to better predict risk and to execute claims processing at much lower costs (e.g., automated pay-outs based on remote sensing data). New data sources in this context primarily constitute weather data (weather index insurance) and satellites (satellite insurance), which allow experts to analyse farm plots and weather-related risks and yield implications at scale and with increasing nuance and detail even as the costs of such remote sensing data decline annually. More complex D4Ag insurance models involve a triangulation from more

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granular weather data, remote sensing satellite data, ground sensors (e.g., field precipitation monitors) crowdsourced pest and disease reports that allow for more accurate surveillance and projection of pest and disease risks, and more nuanced data about the farm itself (e.g., soil health diagnostics) that enable more refined predictions of yield losses.

Examples of key D4Ag insurance solutions include relatively established and large-scale (in terms of farmers covered) specialist firms like **Pula** and **ACRE Africa** and more recent digital crop insurance entrants like **Oko** and **World Cover**.²⁰⁷ Some of these players focus primarily on data analytics (e.g., Pula, Oko); others are themselves distribution intermediaries – see, for example, **WorldCover** in Ghana and **SumAfrica** in Uganda,²⁰⁸ which identify and acquire clients and service insurance portfolios on behalf of or in consortium with more traditional insurers. Still others focus on delivering B2B insurance products to other farmer financing intermediaries, such as the **WINnERS** model in Tanzania of providing weather (precipitation) insurance coverage to banks that have large smallholder financing portfolios.²⁰⁹

In addition to D4Ag insurance players who partner with insurers and other traditional financial institutions, an alternative distribution

channel that is gaining in popularity is the bundling of digitally-enabled agri-insurance products into MNO farmer advisory and payment services. For example, **Econet** in Zimbabwe offers its **EcoFarmer** insurance product – weather-indexed insurance for which the pay-out is dependent on abnormal rainfall and all premium and claim payments are processed via digital channels.

Digitally-enabled smallholder farmer insurance solutions are growing in scale and have significant promise, but many barriers likely still need to be overcome before the African market will see mass-scale uptake of agri-insurance. Recent reviews of the smallholder agri-insurance opportunity broadly, and D4Ag solutions for insurance in particular, suggest reason for optimism but while also sounding notes of caution. IFC’s late-2018 overview of the D4Ag insurance opportunity has concluded, for example, that developing D4Ag “insurance schemes that balance commercial viability of a product linked to a volatile sector where risks are not easily mitigated and the need to compensate farmers when they experience agricultural losses remains a challenge”, and highlights that while there is a good deal of promise and some scale for products like index insurance, “most products in this space, including those enabled by digital technology, have yet to exit the pilot stage.”²¹⁰

EcoFarmer



A more in-depth recent study by the Initiative for Smallholder Finance (ISF) has likewise highlighted the challenges of supplier economics (e.g., economically viable distribution models) and the demand-side challenge of the fact that “the vast majority of smallholders still don’t understand, trust, or see sufficient value in the products that are available”. ISF’s review cautiously concluded – and this report’s authors concur – that despite many achievements to date and the important contributions of D4Ag innovators to the sector, “agricultural insurance for the smallholder farmer market likely requires another five to ten years of product, process, and technology innovation to break down complexity and continue to expand the realm of the possible.”

Index insurance, for example, holds strong promise in terms of allowing providers to create business and operating models that can be commercially scaled and sustained in rural geographies provided the pool of policyholders is large enough and adequately dispersed geographically to distribute risk.

Financial Access – Data Analytics and FSP Digitalisation

One cross-cutting challenge for many financial service provider types in the smallholder farmer financial access

space (e.g., banks, MFIs, SACCOs, MNOs) is the FSPs’ limited institutional capacity for digitalisation; this is an opportunity that a number of D4Ag solutions are now attacking with B2B service delivery models. While scaling up D4Ag financial access products requires overcoming many other demand- and supply-side challenges, one common thread is the constrained ability of traditional, ‘analogue’ FSPs to rapidly design, prototype, and deploy digitally-enabled products for farmers.²¹¹ Most FSPs struggle, for instance, to develop state-of-the-art in-house data analytics capacity. Many find it hard simply to build up sufficient management sophistication on data analytics or bring their internal data systems to a sufficient state of digitalisation to effectively interface with third-party analytics vendors who can help. More prosaically, many African FSPs struggle with even more basic digitalisation initiatives such as digital data capture and records management, the build-out of digital communication channels with clients, or the digitalisation of internal credit risk assessment and monitoring functions. The challenges are in part due to resource constraints and the often very long timelines of internal ‘digital transformation’ initiatives. Another underlying challenge is one of institutional incentives, particularly in the lower levels of incumbent organisations, where digital technologies are more often seen as a threat than an opportunity.

Cecilia Schubert, CCAFS





Cecilia Schubert, CCAFS

An emerging cluster of D4Ag solutions are focused on these FSP challenges.

Financial analytics D4Ag enterprises

specialise in collecting and analysing data on the financial habits of farmers and triangulating such information with alternative data sources including satellite data, weather data, and soil quality data.²¹² These approaches use a variety of basic and advanced technologies to analyse this data in value-added ways and to deliver risk assessment insights to financial institutions such as banks, insurance providers, and MFIs. Key innovators in this space include players such as **FarmDrive**, **Harvesting**, **YAPU**, and **SatSure**.²¹³ Other initiatives – such as a collaboration between **Rabobank Foundation**²¹⁴ and **MUIIS project**²¹⁵ and a CTA-led initiative with **IGTF** and **NUCAFE**²¹⁶ are using this model to increase access to smallholder farmers and cooperatives in Uganda. These efforts also tackle the issue of inaccurate farmer data acting as a barrier to accessing credit. Using detailed farmer registries, including GPS coordinates of farmers' fields, provides a kind of guarantee to FSPs that they are basing their credit decisions on an accurate representation of the smallholder farmers they are working with.

Another important variant of B2B D4Ag solutions in the financial access use case are enterprises that specialise in

FSP digitalisation services. For example, **MOBIS**, **Ensibuuko**'s financial management platform, is a, cloud-based microfinance management platform designed uniquely to help savings and loans cooperatives go paperless and become more efficient by digitising how they manage customer data and transactions.²¹⁷ **MOBIS** serves 50 African SACCOs, which collectively reach close to 300,000 farmers in Uganda and now are expanding in other countries. Similarly, **YAPU** has focused its business model on turnkey digitalisation of the lending, data analytics, and customer engagement processes of FSPs that focus on smallholder farmer finance, particularly small and medium-sized MFIs, allowing such institutions to grow their books and profitability while also boosting smallholder clients' yields and incomes through the benefits of sophisticated weather and satellite analytics.

Macro Agricultural Intelligence

Solving the complex challenges of African smallholder agriculture requires timely, accurate, granular, and large-scale data, combined with insightful analyses.

Such data and insights are often missing today for key macro decision makers including Sub-Saharan Africa funders, government policymakers, and agribusinesses.²¹⁸



A number of disruptive technologies such as remote sensing via satellites and drones, innovations in low-cost and more compact weather station technologies, low-cost/high-throughput soil testing spectrography, and the emerging smallholder-focused internet of things (IoT) are already generating massive new datasets about farm fields and agroclimatic conditions that have not been previously available or have not been available at such low cost to agriculture sector actors. There is a parallel explosion in the volume of geotagged data about farmers and their needs and behaviours (e.g., data from farmer registries, open government agriculture data initiatives, payments companies involved in agricultural value chain digitalisation, and digital credit and insurance providers). The volume and velocity of both of these data universes – data about farms and data about farmers – will continue to accelerate rapidly over the next decade.

In parallel, innovations in data analytics tools and methodologies (e.g., big data pattern recognition, image processing, machine learning techniques) mean that there is now a growing opportunity to bring very different types of datasets together in unique ways to offer decision makers of all types the ability to monitor real-time agricultural trends at large scale and, more importantly, to forecast key

variables of interest like yield projections, crop losses, supply-demand mismatches, agriculture jobs trends, climate-impact indicators, and granular real-time food and nutrition security maps.

This report is not novel in flagging the ‘Data4Ag’ opportunity; many actors have been on initiatives to develop, support and govern this ag data ecosystem for the past 5+ years.

Major examples of initiatives focused on the Data 4 Agriculture ecosystem in recent years include CGIAR’s **Big Data 4 Agriculture** initiative,²¹⁹ ODI’s **Open Agriculture Initiative**,²²⁰ the **Global Partnership for Sustainable Development Data (GPSDD)** (and its agriculture-focused programming),²²¹ and the rapid growth of the **Global Open Data for Agriculture and Nutrition (GODAN)** network.²²² Despite this dynamism in the ecosystem and the growing volumes of data, there is universal consensus that very few agriculture actors in Africa actually use macro-scale data analytics and insights tools that can take full advantage of agriculture data’s potential.

A small but growing number of D4Ag macro agricultural intelligence start-ups

L. Sharma, Marchmont Communications



MACRO AGRICULTURAL INTELLIGENCE

Figure 10 **Macro agricultural intelligence – overview of sub-use cases and solution examples**



are working to fill the data insights gap by putting practical and powerful tools in the hands of African decisionmakers.

We are tracking roughly three dozen D4Ag actors that have macro agri-intelligence as part of their mandate, and under a dozen solutions that have agri-intelligence as their primary focus. A third of these players appeared in the past 1-2 years; 80% of these players are under five years old. Given their recent vintage, most of the commercial players in this segment are still in the pilot or early scale-up stage; only one of the Africa-based enterprises

– Gro Intelligence – has attracted significant commercial investment to date.

D4Ag macro agricultural intelligence solutions include a few very different types of organisations. These include **government or donor ag data analytics and surveillance platforms**; surveillance and (more rarely) forecasting tools, typically focused on weather data or food security but often now starting to integrate other data sources and analytics use cases for the benefit of government decision makers; the agronomy research community and its funders; **commercial agriculture**



data analytics platforms that draw on and integrate third-party data and then put productised self-service data, data analytics and data visualisation tools into the hands of decision makers; **commercial remote sensing and weather data analytics specialists** that have proprietary data collection assets and specialise in specific data types, but also develop value-added data intelligence products marketed to agriculture decision makers or other agri-intelligence intermediaries; and **custom ag data analytics providers** that bundle data and data analytics with consulting and advisory models (e.g., working with agriculture sector investors or specific agribusinesses to deliver value-added market intelligence insights or support specific decisions).

For government and donor agri-intelligence platforms, the most prominent example today is likely the **World Bank Group (WBG) Agriculture Observatory**,²²³ and country-level platforms of a similar type such as **KALRO's Kenya Agriculture Observatory Platform (KAOP)**²²⁴ and a few weather surveillance observatories, which are likewise primarily supported by the World Bank. Other examples of large donor-funded agri-intelligence platforms include **FEWS NET**, the leading famine early warning and surveillance system that has been in place for decades but

has in recent years significantly broadened its use of data sources and its deployment of analytics techniques;²²⁵ **GeoGlam**, a donor-funded global agricultural monitoring platform that runs tools like the Global Crop Monitor for early warnings focused on assessing and forecasting crop conditions in countries at risk of food insecurity;²²⁶ and more recent arrivals like the **World Food Program's Vulnerability Analysis and Mapping (VAM)** platform²²⁷ and Africa country-specific agriculture surveillance platforms currently being piloted by **CropWatch**, China's leading crop monitoring system, for countries like Mozambique.²²⁸

Of the commercial solutions for Sub-Saharan Africa macro agri-intelligence analytics and visualisation, **Gro Intelligence** is the Africa market leader.²²⁹ The company focuses on aggregating and integrating disparate agriculture datasets – most notably, government agricultural data, weather data, soil data, and satellite data imagery – and then translating that data into trend analysis, useful visualisations, and (for some variables like yield) different types of forecasts. The data are marketed to a variety of end-users across government, agribusiness, and the private sector, but the company's focus is on more commercial (agribusiness and commodity investors) decision makers.

Other commercial macro agri-intelligence players tend to focus on both self-service data decision tools and bespoke agri-intelligence analytics for private sector and public sector clients. Examples of such solutions include **Tata Consultancy Services (TCS) AgEye**,²³⁰ **SatSure's 6th Grain**,²³¹ **McKinsey's ACRE**,²³² and **Dalberg's CubicA**.²³³ Finally, a number of players specialise in satellite or weather data analytics for agriculture with a strong focus on macro agri-intelligence applications. **AWhere** is the most established example of such solutions for agriculture-related weather analytics. In the satellite data space, interesting examples include **SatSure**²³⁴ and **Satelligence**.²³⁵

World Bank



Georgina Smith, CIAT



Global big tech players like **Microsoft** (via their **Microsoft AI for Earth team**)²³⁶ and **Google** (**Google Earth Engine**)²³⁷ are also exploring macro agri-intelligence applications that have relevance for Africa, but have not yet developed their tools into products targeted at the agricultural space in the region.

The macro agri-intelligence opportunity is still in its very early days and commercial prospects for many of the models are uncertain, but we are likely to see many new solutions in the next few years.

From the perspective of government and donor-funded macro agri-intelligence platforms, our expert interviews suggest that we are on the cusp of significantly increased investment into national agri-intelligence system development, either as stand-alone projects or as knowledge and monitoring and evaluation (M&E) investments bundled into much larger national agricultural transformation

programmes (e.g., World Bank's Kenya agriculture transformation programme and its KAOP component).

In the case of more commercial macro agri-intelligence solutions, as noted above, most of the actors in this category are at an early stage of proving their value and business models. Furthermore, despite growing interest, data and data analytics monetisation in the context of developing Africa is still a very difficult business with sceptical and resource-constrained institutional clients and fairly risk-averse agribusinesses (when it comes to paying for third-party data and data analytics technologies). This makes the economics of stand-alone macro agri-intelligence businesses challenging in the near term; however, since macro agri-intelligence is often a supplementary or ancillary data stream for many players in the sector, experimentation and market entry will continue to grow quickly even if it outpaces commercial viability for many actors.



Farmerline



An Emerging D4Ag Use Case – D4Ag ‘Super Platforms’?

There is an emerging D4Ag use case of ‘super platforms’, solutions that bundle multiple D4Ag services and deliver a fully integrated digital value proposition to smallholder farmers and other agricultural value chain intermediaries.

D4Ag ‘super platforms’ are solutions that straddle many – and, at times, all – other D4Ag use cases. At the very minimum, super platforms combine digitally-enabled market linkages, digital finance, and digital advisory services into an integrated service bundle for farmers. When they operate at scale, these platforms can deliver immense value to smallholder farmers, greatly reduce risks and transaction costs for all agriculture value chain actors and, at the same time, generate attractive economics for D4Ag enterprises.

We have adopted the term D4Ag ‘super platforms’ – a helpful encapsulation of the scope and ambition of such business models – from MercyCorp’s AgriFin Accelerate team.²³⁸ Other names for these models or analogous concepts in the literature include holistic service delivery models (SDM) and ‘integrated digital agriculture marketplaces.’²³⁹ Although they are not yet

a fully distinct and mature use case – many D4Ag enterprises are just beginning to build out their service bundles and to refine their value proposition – **D4Ag super platforms** were repeatedly highlighted in our expert interviews as a fast growing and highly promising path forward for the sector. The report’s authors strongly endorse this view.

D4Ag super platforms link farmers to buyers and to the broader ecosystem of finance, advice, and other services, thereby eliminating layers of intermediaries and creating immediate economic value.

While there are many variations of these models, all super platforms follow the logic of value chain supply and demand aggregation and formalisation. Typically starting with digital payments, often bundled with digitally-enabled off-take linkages, these solutions result in more reliable access to markets, which, in turn, encourages farmers to invest in productivity enhancements – most notably, the purchase of farm inputs. Farmers buy the necessary inputs through the super platform due to convenience, more attractive prices (i.e., improved bargaining power vis-à-vis input sellers), and strongly aligned incentives on input quality, since the super platform also partakes in the upside of higher farmer productivity and incomes.



SUPER PLATFORM SOLUTIONS

Figure 11 D4Ag super platform solution examples



Smallholder farmers also have an incentive to access credit (and bundled agri-insurance) from the platform. These financial services are likely to be far more affordable than alternatives due to the super platform's privileged access to the farmer's data and, most importantly, its ability to monitor input purchases or off-take transactions. Digitalised advice and information supports and de-risks every step of this journey by helping smallholder farmers minimise risks of crop loss, improve their financial literacy and agronomic practices, and understand off-take market needs and quality requirements. Finally, super platforms can also include digital supply chain management services to

ensure cost-efficiency, support traceability, and improve time to market.

The core insight of emerging D4Ag super platforms is that product and service bundling is essential to unlocking maximal smallholder farmer impact and maximally attractive economics for D4Ag intermediaries.

Service integration, in the highly fragmented and inefficient market environments that characterise smallholder farmer agriculture in Africa, can create surprising levels of synergy in terms of doubled or even tripled farmer yields





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and incomes, operational efficiencies, improved farmer trust and loyalty, quality control over value chain inputs and outputs, and valuable data and insights.²⁴⁰ Service bundling can be very costly for D4Ag enterprises, but successful D4Ag super platforms ultimately generate the arbitrage opportunities and overall increases in economic value that single-use-case D4Ag solutions are never able to achieve. Over time, this compensates for the incremental costs and complexity of bundled service delivery.

A related insight for super platforms is that in rural smallholder farmer markets that lack vital infrastructure, particularly agricultural finance and logistics infrastructure, the combination of human agents and digital technologies can meaningfully plug many of these gaps. D4Ag super platforms do not just leapfrog infrastructure gaps; rather, they often fill them with new and essential physical and human last-mile infrastructure (e.g., market and knowledge facilitation agents, input/off-take aggregation points, storage facilities, knowledge hubs, and payments hubs). Super platforms can deploy and maintain such infrastructure at a reasonable cost due to scale and network effects (i.e., many uses for physical infrastructure and field agents to ensure high utilisation) and through efficiency gains delivered by digital technologies.

While D4Ag super platforms share value chain aggregation features, emerging models are very diverse.

Solutions in this category vary across several different dimensions including **player type**, the **scope of services offered** (i.e., number of use cases covered by solution), the depth and **sophistication of each service** (e.g., light touch farmer information services vs. in-depth precision advisory), the **level of human intermediation** involved, and the **approach to service bundling** (i.e., multi-player partnership/consortia vs. integrated super platform solutions that build and deploy all services in-house).

The first important dimension to consider is the **type of player** that is promoting the D4Ag super platform products, as approaches, constraints, and incentives differ substantially by actor type.

As illustrated in Figure 11, the range of players who have built, are building, or may aspire to build D4Ag super platforms in Africa is very wide.

On the government side, the two most prominent government-linked platforms are the **SNS** in Rwanda²⁴¹ and, at an earlier stage, ongoing efforts by **ATA** in **Ethiopia** to consolidate national-level digitalisation initiatives and assets into a more integrated national advisory, market linkages, payments, and financing platform.²⁴² Globally, another example of government-led D4Ag super platform's is India's **eNAM** platform, which several African governments have been studying with an eye to replication.²⁴³ Another non-commercial example of note, this time from a public-private consortium, is the **Farm to Market Alliance (FtMA)**, which is building out an ambitious digital platform that integrates sophisticated digital (precision) advisory, digitally-enabled input and off-take market linkages, supply chain management, and digital finance (payments, credit, and insurance).²⁴⁴



The second clear cluster of D4Ag super platform designs are models driven by different types of financial service providers. These include several of the very largest D4Ag solutions in terms of reach that we are tracking across the entire region.

KCB's large and rapidly expanding **MobiGrow** platform, which already combines elements of advisory services, market linkages, and payments and credit, is the most prominent example of a bank-led super platform, though other banks such as **Opportunity International** and **Advans** are also experimenting with elements of this model.²⁴⁵

For the MNOs, super platforms are also an attractive opportunity to tap into agricultural payment digitalisation revenues and other ancillary revenue streams.²⁴⁶ The best known example is **Safaricom's Digifarm** solution, which already features advisory services, credit extension, and input-side market linkages, and is planning to both deepen (e.g., moving to more precise advisory service) and broaden the range of digital services on the platform.²⁴⁷ **Econet**, via its **EcoFarmer** D4Ag platform,

already covers advisory services, payments (**EcoCash**), and agri-insurance. Digitally-enabled value chain market linkage services are in the product pipeline.²⁴⁸

Several leaders from the payment space are also pursuing the super platform opportunity. Most notably, **MasterCard**, as part of **MasterCard's Lab for Financial Inclusion** in Nairobi, launched an ambitious agriculture value chain digitalisation solution in 2017, initially called **2Kuze**, and now operating in East Africa as **MasterCard Farmer Network (MFN)** and in India as **e-Rythu**²⁴⁹ **Cellulant's** new **Agrikore** product, a blockchain-based agriculture payment and market linkage digitalisation solution, also has great aspirations for scale and super platform features.

Another major group of D4Ag solutions pursuing the super platform vision are smaller start-ups in Africa that focus on digitally-enabled market linkages.

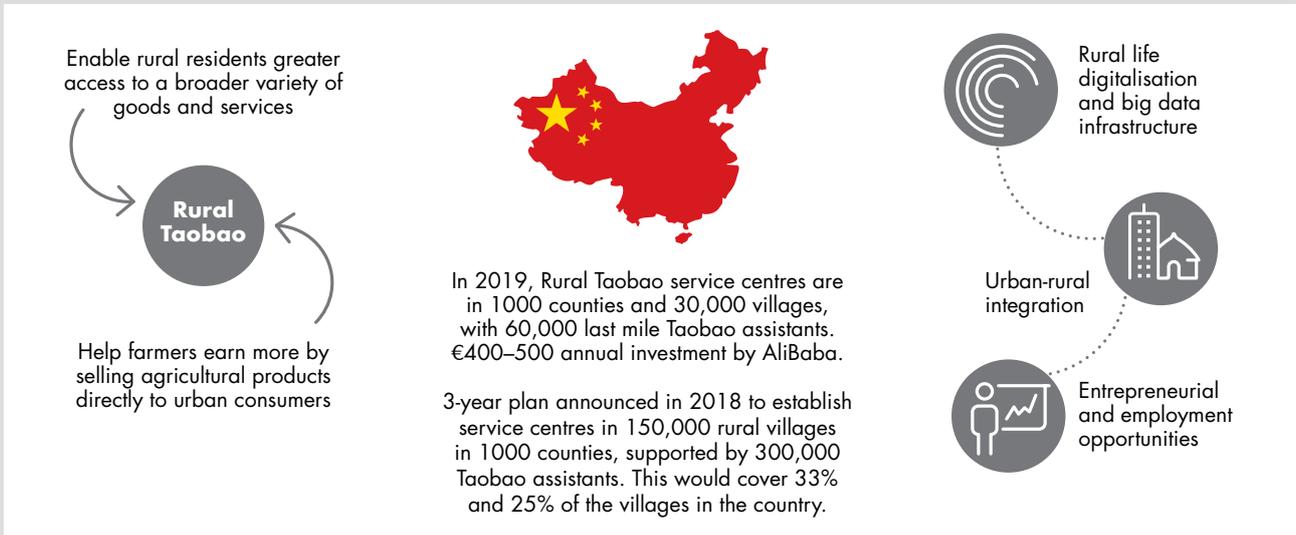
These solutions typically already integrate advisory services, payments, and other value-added financial services; occasionally they also include logistics and supply chain management

Stephanie Malyon, CIAT



AFRICA'S SUPER PLATFORM FUTURE?

Figure 12 Overview of Alibaba's Rural Taobao in China





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services as part of their interaction with input or off-take markets. Several relevant examples include **iProcure**, **Twiga**, and **Tulaa**.

Tulaa, in particular, has already prototyped an end-to-end D4Ag super platform model in miniature as part of its market pilots in Kenya. The **Tulaa** model incorporates agents but also digitalisation throughout the value chain, including digital payment e-wallet, digitally-enabled input and off-take market linkages, the provision of digital credit and, finally, digitalised farmer advisory and supply chain and logistics management features.

While digital market linkages are a typical entry point for such models, several players are exploring a move to a super platform model from the digital advisory angle.

MUIIS in Uganda, a solution funded by the Dutch government and launched by CTA, started with precision advisory and agri-insurance services, but is now moving to integrate more payments, credit, and market linkage elements.²⁵⁰ Similarly, **WeFarm**, the large Kenya-based peer-to-peer digital advisory enterprise, is considering pivoting its model to include digital input and off-take marketplace components, as well as linkages to digital finance.

Another variation of super platforms worth noting are ‘in-house’ D4Ag platforms, such as the **OFSIS** platform that sits at the heart of the organisation’s digitalisation strategy. OFIS is now being supplemented by the newly launched **Olam Digital Origination** platform, which supports direct digital transactions between Olam and its farmers and includes additional features such as traceability, advice to farmers on yield and quality optimisation, and payment facilitation.²⁵¹

The final potentially paradigm-shifting models worth considering are D4Ag super platforms led by global e-commerce leaders. Such platforms are not currently in the Sub-Saharan Africa market but, given the growing interest of players like Alibaba in Africa, the entry of such models into the region in the medium to long term is well within the realm of possibility and could revolutionise the way that African last-mile value chains operate. Alibaba’s Rural Taobao initiative and business model, which is continuing to grow and evolve rapidly in China, shows one logical evolution pathway for the D4Ag super platform concept and – independently of whether a player like Alibaba decides to replicate this in Africa – holds



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many lessons for African D4Ag entrepreneurs, funders, and investors (see Figure 12).²⁵²

At the core of the Rural Taobao concept lies the idea of using a combination of digital technologies and human networks to more closely link China's farmers and rural hinterlands to the economic growth engine of urban China and, ultimately, to global trade networks. The primary entry point for this vision is Alibaba's rural-focused e-commerce strategy, which combines a rapidly growing network of on-the-ground Rural Taobao Service Centres and agents (assistants) with B2C (TMALL.com) and C2C (Taobao) e-commerce platforms and other enabling digitalised logistics (i.e., Cainiao), payments (Alipay), and financial services (Ant Financial) infrastructure, all fully owned by or affiliated with the parent Alibaba Group, China's biggest company and one of the world's most valuable brands.

The vision of Rural Taobao is to use this web of enterprises and digital solutions, on the one hand, to enable rural Chinese access to a broader variety of modern and low-cost goods and services (i.e., agriculture inputs, health, insurance, and modern consumer goods)

and, on the other, to help Chinese farmers earn more by selling their products to urban consumers – while also dramatically improving farmers' productivity and encouraging the growth of value-add rural enterprises through better linkages to farm inputs, mechanisation, and a full suite of relevant financial products.

The central **market linkage engine** of this model gives farmers opportunities to market and sell their produce directly to urban buyers on Taobao, the country's biggest C2C digital marketplace, either directly or through intermediary food and agriculture enterprises that have Taobao 'storefronts'. Farmers can also get linked to markets via agribusiness intermediaries that market their goods on Tmall, the country's leading B2C e-commerce platform. On the input side of the equation, farmers can purchase high-quality and lower-cost agricultural inputs from a dedicated Taobao inputs and mechanisation marketplace, with delivery to rural areas facilitated through Taobao's rural service centres.

From an **advisory and farmer information services** perspective, farmers can receive some advice and support from the trained service centre staff, but also potentially have a



pathway to accessing digitally-enabled precision advisory services powered by Alibaba's Agriculture ET Brain artificial intelligence business. ET Brain currently is only piloting such precision agriculture advisory solutions for larger farms, but may extend this to smallholders in future phases.

From a **logistics and supply chain management perspective**, logistics management, traceability, and other related functions are digitised and managed through proprietary cloud-based software solutions by Cainiao, Alibaba's partly-owned rural logistics partner for the Rural Taobao venture.

Finally, for **financial access**, the entire network is supported by Alibaba's payments (Alipay) and financial services (Ant Financial) businesses, with targeted third-party partnerships (e.g., agri-insurance from China Insurance), all integrated via a common payments network and data collection and analytics infrastructure.

Alibaba has invested heavily into Taobao, on the order of $\square 400\text{--}500$ million annually since the launch of the venture in 2014; the company is projected to continue a similar pace of investment over the next few years – a good indication of the level of investment needed to seriously move rural infrastructure forward. This appears to be yielding strong results, both in terms of financial viability (e.g., financial service and rural e-commerce revenues) and in terms of scale: Taobao has reached likely over 100 million farmers with new goods, services and finance while 60,000

“

Alibaba has invested heavily into Taobao, on the order of $\square 400\text{--}500$ million annually. ”

last-mile agents staffing Taobao's service centres have covered 30,000 villages – a strong foundation for future growth and impact.²⁵³

The Taobao super platform model deserves close monitoring by anyone thinking about the future of the D4Ag space in Africa. Despite vast differences in cultural and economic context, there are many parallels between the Taobao Rural context and the Africa agricultural transformation vision and, more broadly, Africa's rural infrastructure and jobs challenges. One important lesson is likely to be the scale of investment required – Alibaba alone is investing 10x annually in Taobao what the entire private sector investment community is investing in all of Africa's D4Ag enterprises each year. Another obvious point is the value of fully-integrated and digitised super platform models for the African context given the growing (though anecdotal) evidence of Taobao Rural's successes. Finally, the Taobao case is an important example of the value of melding of digital tools, physical infrastructure and human last-mile networks. Purely digital models have their place, but optimal impacts and economics are unlikely to be achieved without using human agents – supported with digital tools – to facilitate markets, provide advice, deliver financial services, and support last-mile logistics in places where rural infrastructure is weak or entirely absent.



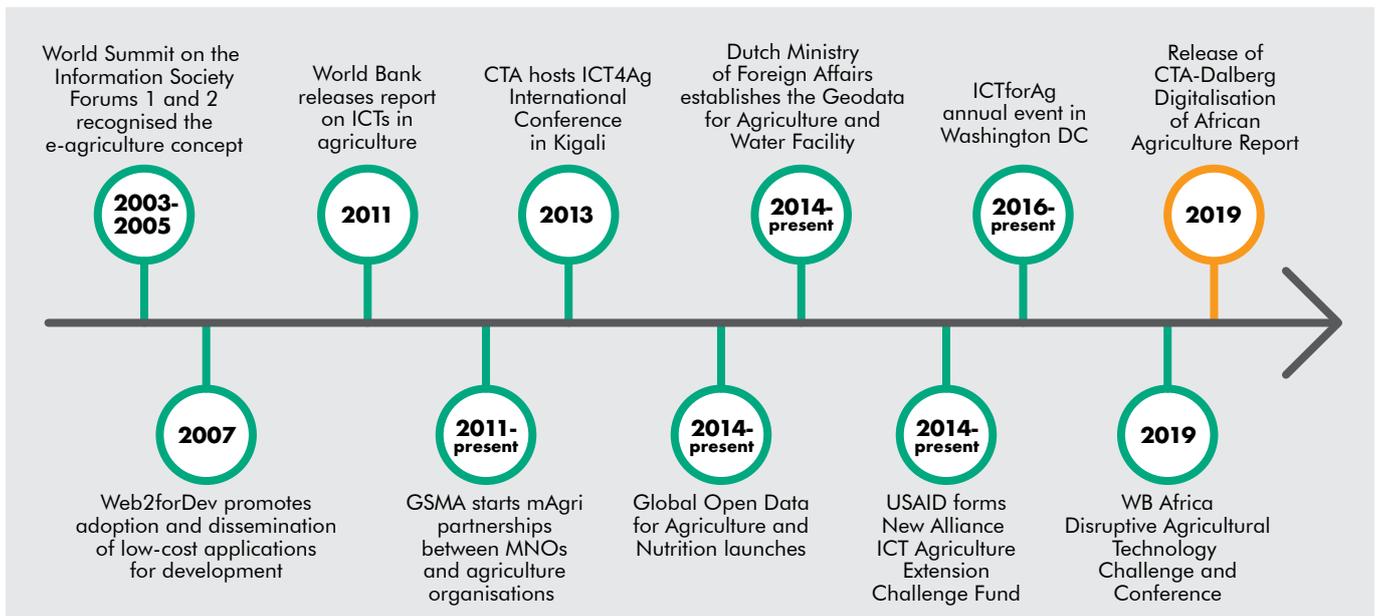
THE EVOLUTION OF D4AG SOLUTIONS



Farmerline

Led by a handful of strong players, the sector is growing rapidly. D4Ag solutions already reach up to 13% of Africa’s smallholder farmers and generate up to ~€144 million in earned revenue annually, with growing evidence of the sector’s positive impact on smallholder farmers.

Fig 13 Sector timeline – from ICT4Ag to D4Ag



D4Ag solutions have multiplied in number

Prior to 2010, conversations about digitally-enabled agriculture had already begun – primarily among donors and multilateral agencies – but there were very few D4Ag solutions in Africa or globally.²⁵⁴ The few enterprises that did exist were just starting to offer basic solutions like market prices, weather information, and generic agronomic advice using SMS/USDD messages over common feature phones. These early discussions, partnerships, and sector convenings (shown in Figure 13) and the intensive experimentation during the ICT4Ag age helped set the stage for the transition to the D4Ag era over the past 5-10 years.

Digital solutions have skyrocketed in number (see Figure 14).²⁵⁵ CTA is tracking more than 460 solutions; of these, as of February 2019, 390 were active and providing useful services.²⁵⁶ This number is high given that nearly 60% (227 out of 390 active solutions) launched in the last three years, and nearly 20% of the total have launched since early 2018.²⁵⁷ Moreover, 90% of these solutions are being offered by unique enterprises.²⁵⁸ These totals are also conservative: our research likely did not uncover all active solutions in Africa, and we exclude data on hundreds of time-delimited, donor-funded ‘deployments’ and ‘projects’ that have utilised digitally-enabled agriculture services in Africa in recent years but are not stand-alone enterprises or organisations with ongoing operations.²⁵⁹

Almost two-thirds of the solutions we have tracked report either advisory or market linkage solutions as their primary use case (Figure 15). Advisory services [137] have been popular among donors and private enterprises because of their ease of delivery; unlike other use cases, farmers’ receipt of information does not necessarily require coordination with other market actors or institutions – or as deep an understanding of specific local value chains. Market linkage

Figure 14 **D4Ag solutions by year of launch**

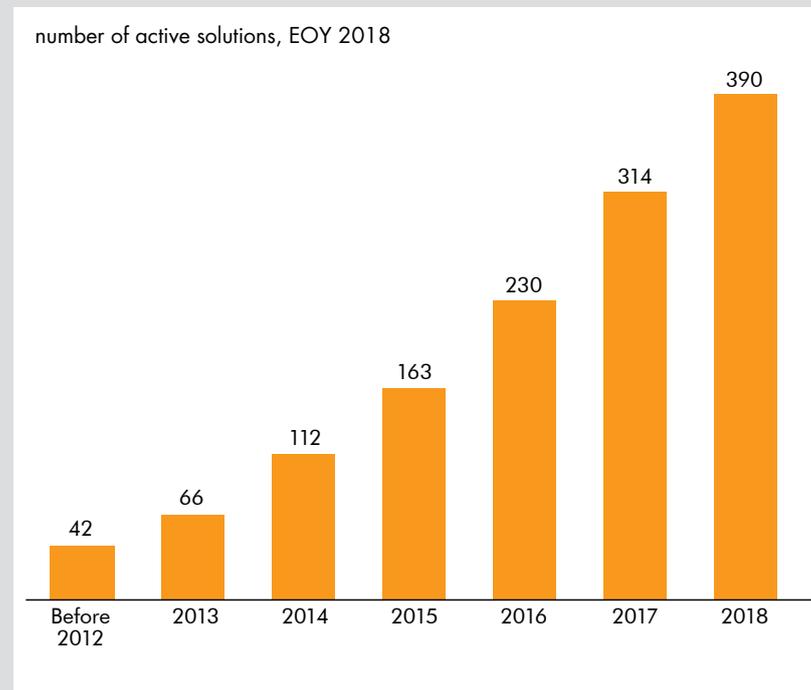
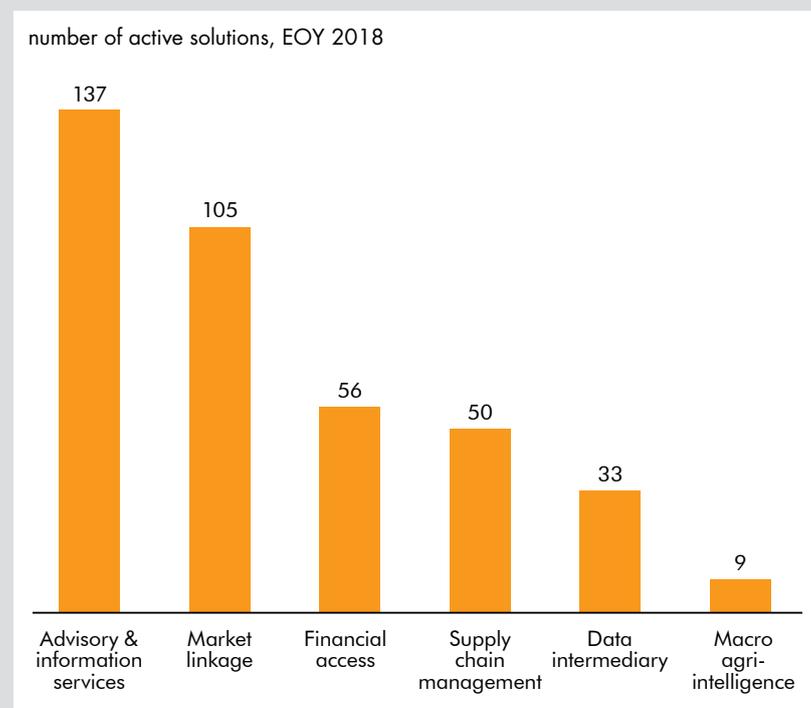


Figure 15 **D4Ag solutions by primary use case**



solutions (105), though more difficult to develop and implement given the higher level of investment typically required per farmer reached, have also begun to grow in number.

The financial access, supply chain management, and macro agri-intelligence use cases are at an earlier stage but are developing rapidly.

Financial access solutions (56) are typically complex, requiring the collaboration and partnership of multiple actors (e.g., banks and mobile network operators) and often building on the existence of key enablers, particularly mobile money.²⁶⁰ Supply chain management solutions (50) typically require relatively large enterprise-quality software investments in order to be considered by agribusiness users, are subject to network effects, and require large numbers of clients to ensure viability – all of which limit the number of deployments. Macro agri-intelligence solutions (9), meanwhile, require a more advanced D4Ag infrastructure

and, most notably, access to large and relatively low-cost datasets and advanced data analytics (e.g., machine learning, AI), which were either not available or too costly until just a few years ago.²⁶¹ As underlying technologies have matured and spread, supply chain management and macro agri-intelligence solutions have grown in number and scale. We expect this trend to continue.

Digital farmer registration figures are growing rapidly

We estimate that the number of farmers registered for D4Ag solutions in Sub-Saharan Africa has grown at roughly **44% per year over the past three years**, and likely in the range of **50–60% CAGR over the past eight years**, to reach a total of **33 million smallholder farmers** as of the end of 2018.^{262, 263} The definition of registered users requires clarification (Figure 16).

Figure 16 **Sizing the number of registered D4Ag users – methodology considerations**

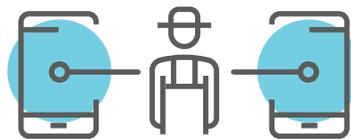
Individuals vs households

This estimate counts users that may be households or individuals using the same device.



Duplication

This estimate includes duplicated users (e.g., one farmer registered for multiple D4Ag solutions). We later apply a 20% haircut to account for this.



Apples and oranges

This estimate includes users of passive solutions (savings accounts) and active solutions (market linkage apps) though use has different implications in these cases.

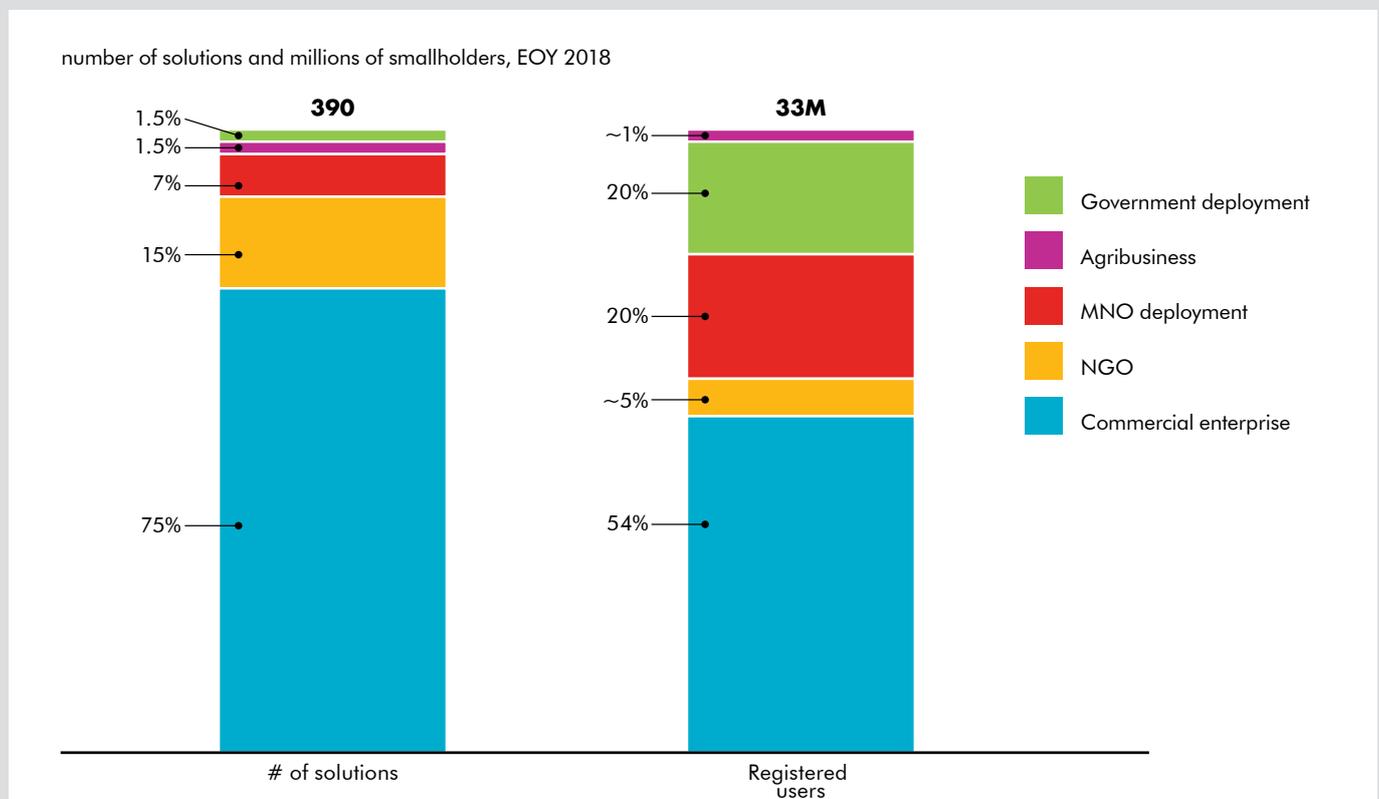


Depending on numbers used to size the overall smallholder farmer population (i.e., individual farmers and pastoralists vs farm households), this figure represents **13%** of all smallholder farmers in Sub-Saharan Africa and up to **45%** of all smallholder farmer households in the region (the highest end of the range assumes only one user per household). The number includes farmers that have either registered themselves for D4Ag solutions, have been registered by agents, or have been registered through an enterprise (typically an agribusiness, cooperative, or financial institution) that uses a D4Ag solution provider to reach and manage relationships with smallholder farmers in its value chain.²⁶⁴ These numbers do not include registrations of non-farmer end-users like extension agents, government end-users of decision tools, and enterprise clients. Such actors are also users of D4Ag solutions but we do not include them here as we were not able to capture them reliably (and they were not our focus segment).²⁶⁵

The definition of ‘registration’ depends on the type of solution – a farmer may be registered for an MNO simply by providing a name and phone number or texting a short code to register for the service, while registering for a government-provided solution might involve sharing census-level details. The overall figure of 33 million does not, however, account for the possibility that some proportion of registered farmers have been registered with more than one D4Ag solution, and are therefore doubly counted.²⁶⁶

D4Ag enterprises (including both commercial and non-profit) account for the majority of registered smallholder farmers. Commercial enterprises and NGOs collectively reach approximately 60% (a maximum of 20 million) of registered smallholder farmers (see Figure 17). This number includes financial service providers (FSPs), which currently reach ~5.5 million farmers through digitally-enabled insurance,

Figure 17 **D4Ag solutions and registered users, by type of actor**



MNO D4Ag solution example

Safaricom is the largest MNO in Kenya and has been a clear pioneer in the D4Ag space. Safaricom’s M-Pesa, one of the first mobile money platforms, has been a critical enabler of D4Ag in Kenya – numerous enterprises that rely on M-Pesa to operate might very well not exist without Safaricom’s leadership. Safaricom has also rolled out a suite of financial and information services for smallholder farmers through DigiFarm, which offers “discounted products, customised information on farming best practices and access to credit and other financial facilities.” Since its launch in 2017, DigiFarm has rapidly expanded throughout the country, reaching a reported 950,000 users, 20% of whom are active.

savings, and credit solutions. As mobile payments become mainstream in many countries, recent growth in FSP activity is likely to continue.²⁶⁷

Mobile network operators (MNOs) and governments each account for roughly 20% of registered smallholder farmers.

MNOs have at least 6.5 million smallholder farmers registered to their D4Ag solutions, typically advisory and information services delivered with other partner organisations. Six major MNOs across the continent currently offer a total of approximately 15 D4Ag solutions.²⁶⁸ Governments similarly reach about 6.5 million farmers through their own D4Ag solutions.

Large agribusinesses such as Olam,²⁶⁹ Cargill, Mars, and ETG likely reach no more than 500,000 African smallholder farmers with proprietary (in-house) digitally-enabled supply chain management solutions.²⁷⁰ In large

part, this relatively low number is due to the fact that most agribusiness solutions target smallholder farmers in tight value chains – and such farmers represent a maximum of 7% of smallholder households.²⁷¹ Input dealers like Yara and Syngenta and mechanisation players like John Deere are also active in the D4Ag sector; for the most part, these players, as well as big buyers and processors like Barry Callebaut, have partnered with other organisations to digitise their farmers or use third-party supply chain management solutions, so we capture their potential reach within the D4Ag enterprises category (e.g., Barry Callebaut’s reach counted as part of the SAP Rural Sourcing Management Platform).

‘Engaged’ and ‘active’ users make up a minority of registered users

We estimate that 42% of registered smallholder farmers have engaged with D4Ag solutions to some extent – in the

Figure 18 **MNO D4Ag solutions in Africa (EOY 2018)**

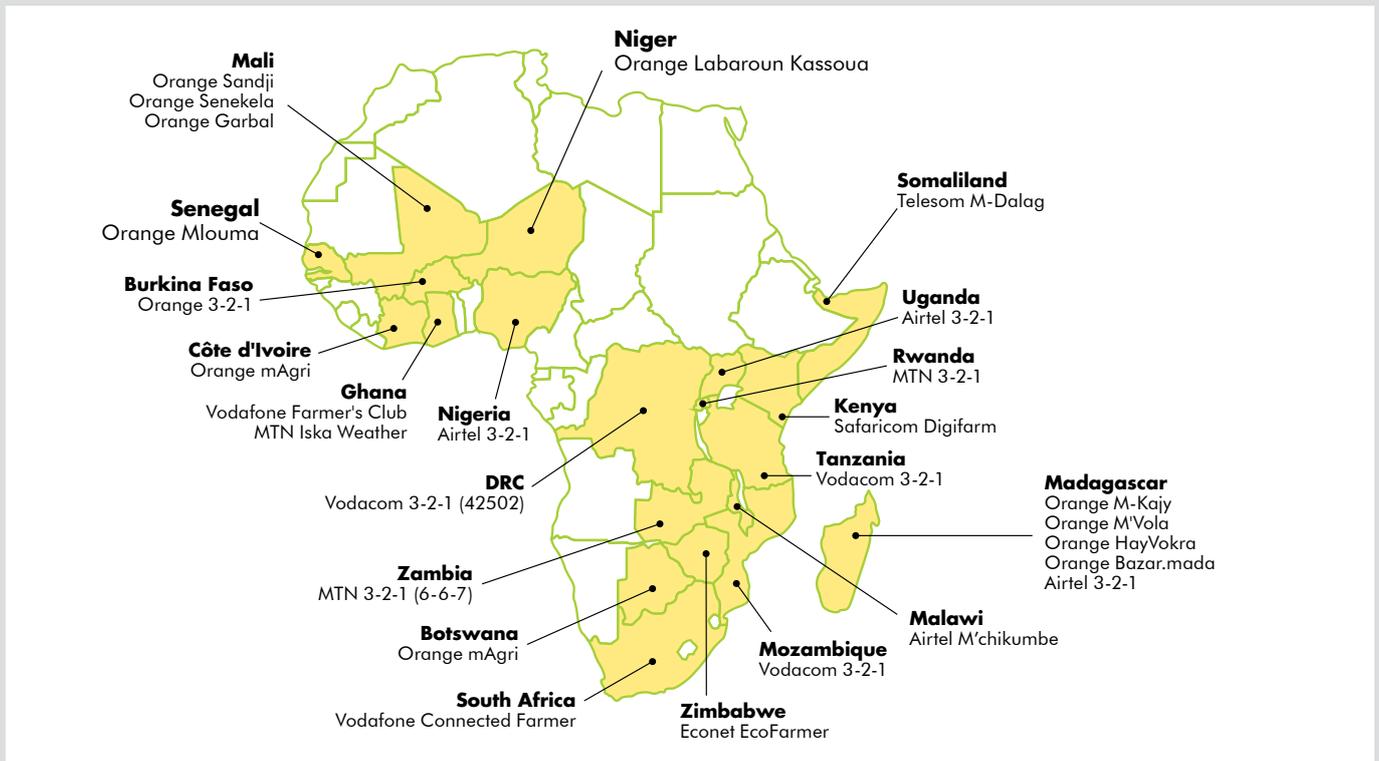


Figure 19 Definitions of D4Ag user types



case of most solutions, at least once monthly in the past year.²⁷² We propose engaged users as a new term to filter out farmers who are registered for digital solutions but do not use them, while also acknowledging that truly active users are currently difficult or impossible to measure in a report of this type due to the lack of consistency in definitions and the absence of comparable data. The estimate of engaged users is based on CTA-Dalberg survey data and augmented with desk research and interviews with implementers of large D4Ag solutions that did not respond to the survey – but it should not be interpreted as suggesting that the farmer is necessarily the direct user. ‘Engaged’ in this case might mean that each farmer included in this estimate has used a D4Ag solution, but it could also mean that someone – such as an agent – has helped the farmer use the application, or used it on the farmer’s behalf. Our database tracks 9.5 million ‘engaged’ users of D4Ag services, which constitutes 42% of the registered users (23 million) for whom an estimate of engaged users is available. Extrapolating to the broader D4Ag population suggests that there were ~14 million ‘engaged’ farmers utilising D4Ag solutions in 2018.

Estimating ‘active use’ – use of a digital solution frequently enough to obtain or even maximise its target benefits – is at this stage impossible, as noted above, due to the varying definitions of active use

from one solution to another, lack of standard active use definitions even within specific use cases, and the varying levels of use necessary to realise the benefits of a solution (for example, market prices might need to be accessed daily while planting guidance might only be helpful annually). The lack of a meaningful definition of ‘active use’ or sufficiently precise data to give it parameters suggests a need for further data collection, analysis, and study on the part of enterprises, donors, and others. In any case, based on interviews and data from those studies that have attempted to measure different levels of farmer activity for specific D4Ag solutions (e.g., GSMA’s MNO mAgri case studies), it is clear that the level of truly active use is in many cases far below engaged use – e.g., active ‘power users’ accounted for just a third to half of engaged use levels in the case of many MNO solutions, leading to our provisional estimate of active users being 15–30% of registered users, cumulatively, across all use cases.²⁷³

Registrations are highly concentrated

D4Ag registrations of smallholder

farmers are highly concentrated by use

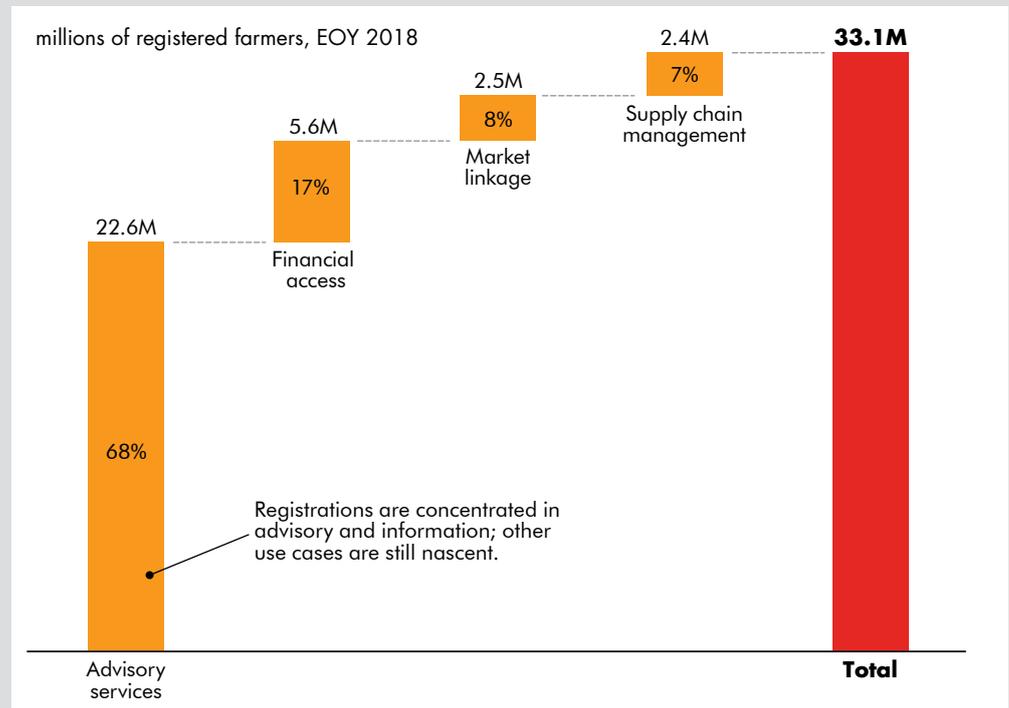
case, actors, and geography. Advisory services account for over two-thirds of registered farmers today, the top 20 players reach more than 80% of registered farmers, and nearly 70% of all registered farmers are in East Africa.

Agribusiness examples

Igara Tea Growers Factory (IGTF) and CTA, in partnership with the consulting firm Environmental Surveys, Information, Planning and Policy (ESIPPS), built a spatial data management system. The digital profiling of tea farmers involved compiling geo-referenced information about them and their land using GPS-enabled tablets. The data are stored and spatially analysed by an online system. The profile database is linked to a financial and accounting system, allowing smallholder-owned IGTF to build track records of transactions with member farmers. The system can thus serve as a basis for fertiliser distribution and tracking. IGTF has benefitted tremendously from this digital solution, which is currently being scaled up at the national level.

In 2014, **Olam International**, one of the world’s largest suppliers of cocoa beans and products like palm oil, coffee beans, cotton and rice, developed an in-house Olam Farmer Information System (OFIS) – a digital supply chain management and advisory solution. Since then, it has been refining the solution and scaling it across its ecosystem of smallholder farmers. Sub-Saharan African farmers constitute a large share of the 160,000 smallholder registered for OFIS and Olam expects to digitise all 500,000 of its farmers globally by 2020. Beyond OFIS, in 2019, Olam announced the launch of their Digital Origination platform, which supports direct digital transactions between Olam and its farmers and includes additional features such as traceability, advice to farmers on yield and quality optimisation and payment facilitation.



Figure 20 **Smallholder registrations, by primary use case**

Note: This count excludes solutions with indirect reach – such as FarmRadio and Agribusiness TV, which reach tens of millions of farmers. Also excluded are farmers registered by business to business solutions if those farmers are already counted as part of the user base of a farmer-facing D4Ag solution provider (e.g., Arifu registered users who are also counted as part of Safaricom Digifarm's solution).

Despite significant bundling in the sector today, registrations are heavily concentrated among advisory services

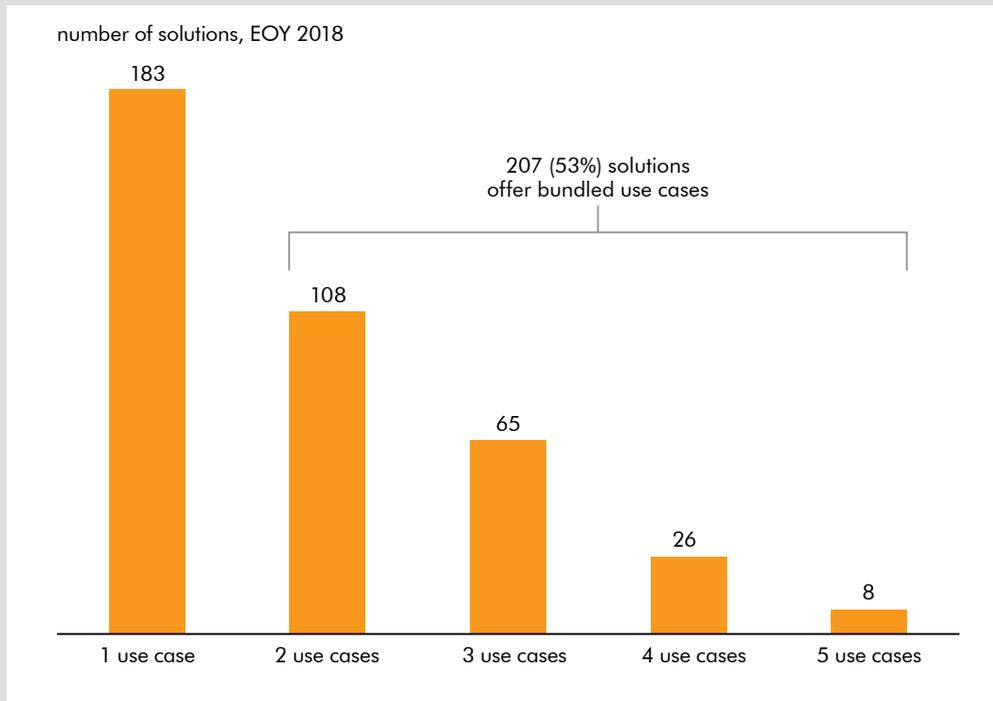
Advisory services account for over two-thirds of registered farmers today.²⁷⁴

This is consistent with the distribution of use cases by number of solutions. (see Figure 20) As discussed above, this concentration is in large part because advisory solutions tend to be easier to scale. Other areas remain more nascent as they require greater feedback from and tailoring to farmers, more complex operational logistics and, in many cases (e.g., for market linkages), the integration of human agent networks, which hampers reach.

D4Ag enterprises are increasingly bundling services across multiple use cases into their solutions. Today, more than half of surveyed enterprises offer services across multiple use cases and ~9% of solutions

straddle 4 or more D4Ag use cases (Figure 21). In the earliest stages of D4Ag, advisory services were easiest to deliver using common technologies. In particular, the evolution of SMS/USSD-enabled enterprises to offer generalised information on feature phones without a need for supporting systems. However, the value generated by such advisory services remained low. In recent years, D4Ag enterprises have looked to combine other use cases, including market linkages, with their advisory offerings. More broadly, as noted in Chapter 2, D4Ag enterprises are increasingly moving toward 'super platform' business models that combine market linkage, advisory services, and financial services, and often also have supply chain management and macro agri-intelligence features. Farmers tend to see more immediate returns from these services, which increases farmer uptake and willingness to pay. Moreover, bundling use cases offers farmers services they need more holistically, enabling greater choice, and drives operational synergies across different solutions.



Figure 21 **D4Ag solutions by number of use cases offered**

Note: Number of use cases offered represents the number of different kinds of services an enterprise could provide users. Bundling presents a unique business model and may result in higher/lower levels of reach, revenues, use, impact, etc.

Registrations are heavily concentrated among a relatively small number of players

The 20 largest D4Ag solutions account for nearly 80% of all registrations (see Figure 21). The scalability of a solution depends on a number of factors, including the enabling environment, market size, revenue model, and value-add, as well as the type of solution sponsor (financial service enterprise, MNO, government, agribusiness). MNOs, for example, may already have direct access to farmers through large agent networks, which likely accounts for the disproportionate number of users registered with this solution type. Other types of players may face the more expensive and time-consuming prospect of having to build out their own agent networks in order to reach individual farmers.

Although most commercial and non-profit D4Ag enterprises are quite small

in reach, several have now achieved meaningful scale. Around 75% of enterprises reach fewer than 100,000 farmers and nearly 30% of enterprises reach fewer than 1,000 farmers. Yet, 16 commercial and non-profit enterprises now have more than half a million users (see Figure 22). In the financial access use category, for instance, the top players are highly concentrated: ACRE's Agricultural Loan Cover (1.7 million smallholder farmers), Bank of Kigali (1.5 million) FarmDrive (1 million farmers), and Pula (600,000 farmers).

Three out of the six MNO players with D4Ag solutions that we are tracking have collectively registered 5 million farmers and account for nearly 80% of farmers reached by MNOs. Viamo has millions of registered users through its 3-2-1 product, Orange reaches at least 1.2 million farmers across ten different D4Ag solutions, and EcoNet in Zimbabwe has 1 million registered users through EcoFarmer. By the time this





Esoko Digital Farmer Service



iCow

Figure 22 Top 20 solutions, by number of registered users

Rank	Solutions	Registered users	Primary use case
1	Ethiopia 80-28 hotline	4,000,000	Advisory services
2	Viamo 3-2-1 (multiple solutions)	>3,000,000 ¹	Advisory services
3	TCS InteGra	2,000,000	Advisory services
4	n-Frnds	>2,000,000 ¹	Advisory services
5	ACRE Africa	1,700,000	Financial inclusion
6	Bank of Kigali/TecHouse	1,500,000	Financial inclusion
7	WeFarm	1,400,000	Advisory services
8	Orange (multiple solutions)	>1,300,000	Advisory services
9	ZIAMIS	1,150,000	Advisory services
10	Esoko Digital Farmer Service	1,000,000	Advisory services
11	Econet EcoFarmer	1,000,000	Advisory services
12	Safaricom DigiFarm	950,000	Market linkage
13	Arifu	900,000 ²	Advisory services
14	iCow	821,800	Advisory services
15	Pula	611,000	Financial inclusion
16	Digital Green	500,000	Advisory services
17	Agroforce/Virtual City	500,000	Supply chain management
18	Waterwatch Cooperative	500,000	Advisory services
19	RATIN	400,000	Advisory services
20	KCB MobiGrow	380,000	Market linkage

¹ Estimated number of registered users that access agriculture content; many more registered users for these solutions overall in Africa (~15 million for n-Frnds and ~10 million for Viamo).

² Large share double-counted with Safaricom DigiFarm.

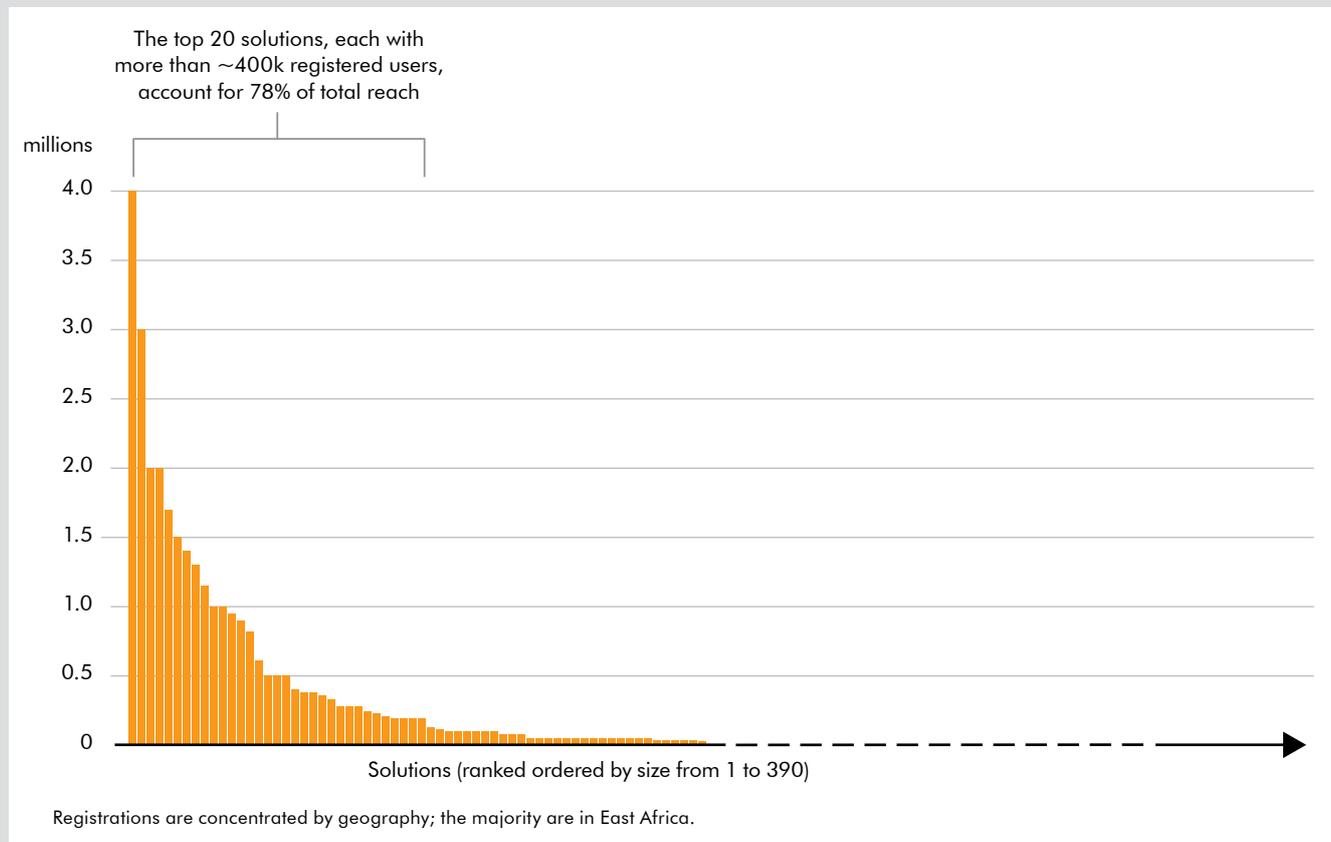
report is published, Safaricom's DigiFarm solution is likely to reach more than 1 million farmers, as well.

Government reach in Sub-Saharan Africa is almost entirely through three solutions: Ethiopia's 80-28 advisory service (4 million farmers), ZIAMIS in Zambia (1.15 million), and Bank of Kigali's SNS solutions, deployed in partnership with Rwanda's Agriculture Board (1.5 million). The latter is currently

rolling out a suite of financial services for farmers in addition to the advisory services it already provides. There are likely other government deployments in the works, but our research did not come across them.

As discussed above, our agribusiness reach estimates are derived primarily from large agribusinesses (e.g., Olam, Cargill, Twiga, SAT4Farming). Olam likely has reached the largest number of farmers to date – the company claims that it has already



Figure 23 **D4Ag solutions by number of registered farmers**

compiled data on 160,000 cocoa farmers. It is likely that the concentration of D4Ag solutions among major agribusinesses may simply mirror the concentration of major agribusinesses in the agribusinesses sector more generally.

Registrations are concentrated by geography; the majority are in East Africa

While D4Ag enterprises are present in nearly every country in Africa, D4Ag has not developed evenly across Sub-Saharan Africa. D4Ag enterprises operate in 43 out of 49 countries in Africa,²⁷⁵ but while at least 17 countries have more than 20 enterprises, 25 countries have fewer than five. East Africa dominates both in terms of registered users (over 20 million) and a high number of active D4Ag solutions, whereas West Africa has

many emerging solutions but the number of registered users remains low (3 million registered by solutions active in West Africa). In contrast, Southern Africa's user base is high (5.8 million) but the number of solutions is limited. Central Africa falls far behind on both fronts (see Figure 25). We will discuss regional variation further in Chapter 5.

Most companies are now generating some revenues

Increasingly, enterprises have been able to generate at least some revenue (Figure 26). Based on the CTA-Dalberg survey data, of the 175 respondents, an estimated 70% of African D4Ag solutions generated some earned revenue – a number lower than the likely 80%+ of D4Ag enterprises in Africa that are revenue-seeking.²⁷⁶ The remaining organisations were either entirely donor- or government-funded entities or were very-early-stage start-ups that



Figure 24 Regional breakdown of D4Ag solutions

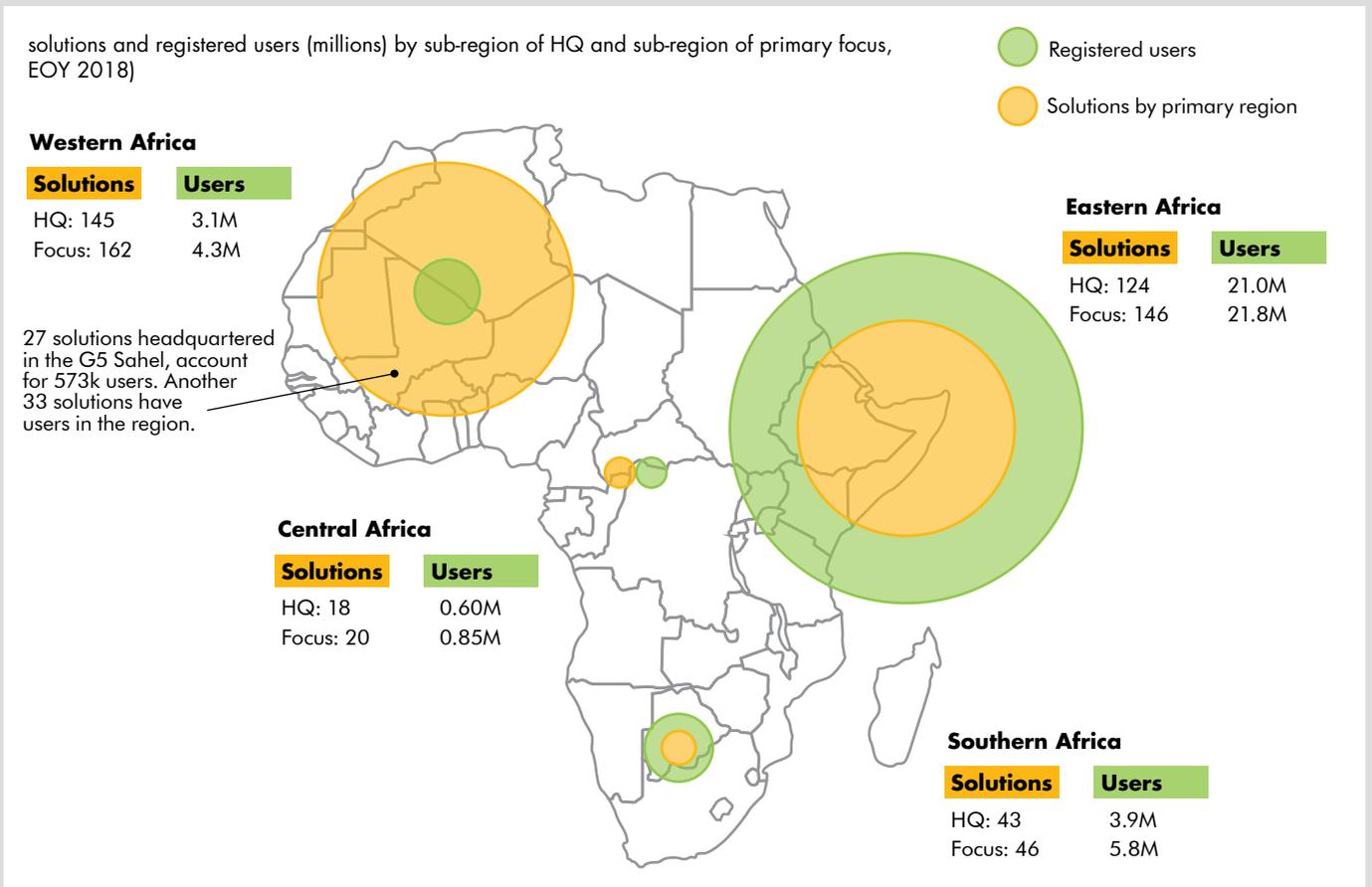
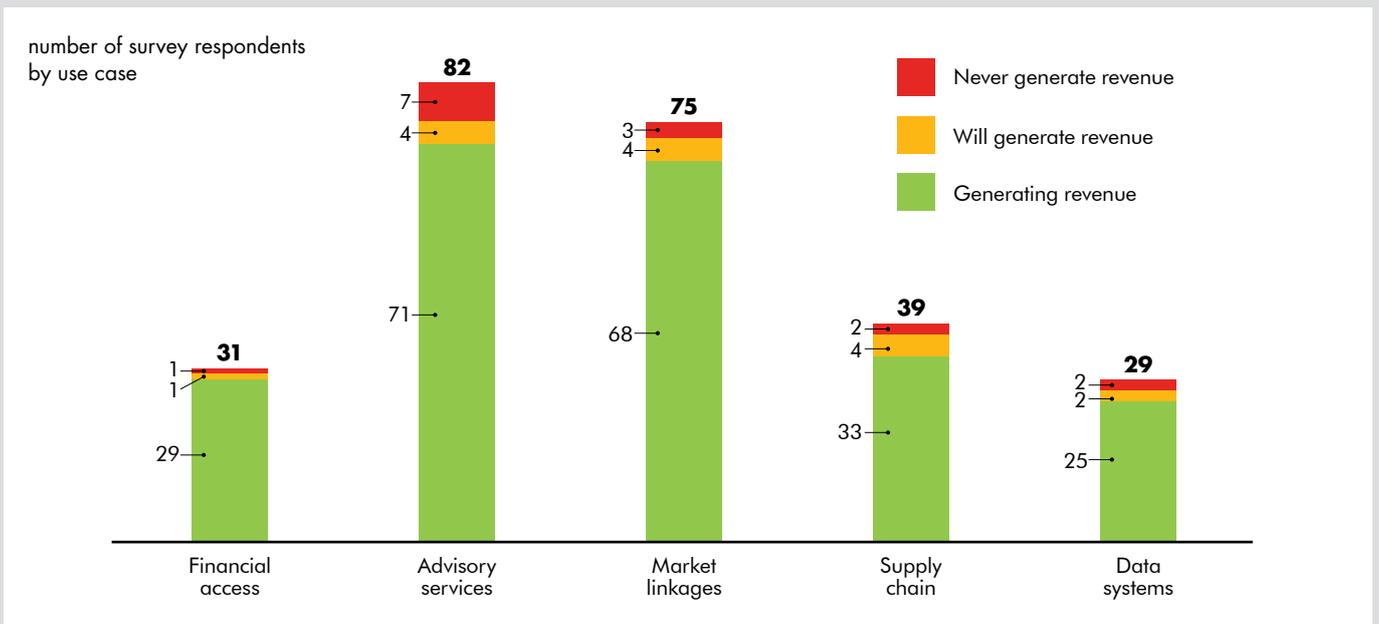


Figure 25 Most D4Ag enterprises are now generating some earned revenues



did not yet report revenue streams. In a few cases, non-revenue-earning solutions were in-house (i.e. non-monetised) digital platforms from agribusinesses or MNO solutions that derived value indirectly without revenues (e.g., 'free' farmer information services that generate value through improved customer retention and stickiness but do not generate direct D4Ag revenues). Around 80% of the revenue-generating enterprises had several revenue streams.²⁷⁷

Of the revenue-generating firms in the survey sample, 26% reported running profitable and sustainable businesses that could survive without donor long-term subsidies, a figure that is within range of earlier D4Ag sector overviews.²⁷⁸ Most D4Ag enterprises are thus largely supported by grants and still have a way to go before they are sustainable and scalable. This profitability number may seem disappointing but is not unexpected. Only 40% of the commercial enterprises in the CTA-Dalberg databases have been in operation longer than three years, which is often seen as a reasonable benchmark for time to profitability for tech start-ups and, more broadly, new small and medium-sized businesses.²⁷⁹ This share of profitability among start-up enterprises is also in line with early-stage start-up investor expectations in Africa.²⁸⁰

Sector economics are improving and the share (and number) of profitable enterprises is growing. While there are no baseline data with which we can make a comparison, anecdotal evidence from interviews suggests that these results are significantly higher than what was common even a few years ago in terms of the share of D4Ag solutions that are profitable. Extrapolating to the overall sector, even assuming very high levels of new business failure (e.g., 50–75% failure rate over three years), these numbers suggest that the number of profitable and thus potentially investable D4Ag actors could double from ~75 D4Ag solutions today to over 150 in 2021.²⁸¹

There is also a clear trend of rising annual D4Ag enterprise revenue per farmer. Self-

reported D4Ag enterprise revenues, expressed in annual revenues per registered farmer, tend to be highest for market linkage enterprises. Aggregating across survey, desk research, and interview data, and rounding for convenience, we see ~\$25 average revenues for market linkage solutions per registered farmer annually (\$3–45 range), in comparison to ~\$5 for advisory and information services (\$1–9 range), ~\$4 for digital financial services (\$0.5–7 range), and ~\$4 for supply chain management solutions (\$1–7 range).²⁸²

As the sector pivots to a greater focus on market linkage (or rather market linkages bundled with other services) from solutions focused more on advisory services – something that we heard universally in our interviews but are unable to demonstrate empirically in the absence of comparable historical data – one would expect that average sector revenues would rise quickly.

A small but growing number of players have already started developing business models that can generate up to \$90 in annual per farmer revenue. Achieving these types of revenues requires multiple revenue streams and extensive product bundling, i.e., characteristics of emerging D4Ag 'super platform' models. To generate such economics D4Ag actors must essentially become active agriculture value chain participants, taking a share of both agricultural input costs and off-take value as compensation for their digital intermediation. This approach can work well when D4Ag solutions are able to successfully consolidate fragmented value chains by removing other intermediaries (e.g., digitally linking farmers to retailers for the post-harvest sale in ways that bypass last-mile village agents and traders), reducing value chain 'leakage' (e.g., using digitised logistics and just-in-time market linkage to significantly reduce post-harvest losses) or, in an ideal state, capturing both of these effects. The substantial surplus value created can then be shared in ways that leave both the farmer client and the D4Ag intermediary with dramatically improved

Revenue generation example – N-Frnds

In Rwanda, N-Frnds understands the tremendous value of data for both banks and farmers and has built a viable business model around it. The company leverages the data it records on transactions between farmers and off-takers to link farmers to banks to facilitate lending opportunities. Smallholder farmers pay nothing for the service; instead, N-Frnds charges banks a small acquisition fee for every loan extended to N-Frnds' network of farmers. In this way, N-Frnds' business model targets businesses that are able and willing to pay for these data, as opposed to farmers who would be unlikely to use the service if they had to pay for it.



economics. The D4Ag enterprise can then further supplement such revenues with ancillary revenue streams such as financial services fees/interest or even data monetisation revenues.

While the cost structure for generating these revenues varies dramatically depending on solution type, there is evidence that some companies are able to achieve 30–40% gross margins. We certainly do not expect all businesses to achieve this level of revenue or margin, but the data indicate that with extensive revenue bundling, strong economics are achievable. This is already a major leap forward from a time when D4Ag solutions centred on advisory services, as that model is marked by low per-farmer revenues and typically razor thin margins.

Important business model shifts account for the high share of revenue-generating enterprises in the D4Ag space. By and large, digital service providers have learned that farmers will rarely pay for digital products and services – and especially advisory services, where it can take time for farmers to realise

benefits (and even if they do realise benefits, they may not attribute the benefits to the advisory service). There are signs of emerging willingness on the part of farmers to pay for market linkage solutions where results are more immediate. Overall, while 70% of revenue-generating enterprises have user payment revenue streams, user payments do not appear to constitute the majority of their revenue.

Because of the challenges of generating revenue from farmers, organisations have oriented themselves to generate their revenues from other businesses, even if the final service is to the farmer.

Such B2B payment models allow for a range of payment streams from players with greater ability and willingness to pay than the smallholder farmer. These models include monetising data and fee for service. FSPs often partner with banks and other FSPs rather than work directly with farmers, while supply chain management enterprises partner with larger agribusinesses. For example, Tulaa relies on commissions from farmer market linkages and related transactions. Farmforce, meanwhile, enables off-takers (processors or agribusinesses)

Figure 26 **Estimated total addressable market calculations**

Solutions	Addressable farmers (million)	Annual revenue per user		Total addressable market (million)	
		(min)	(max)	(min)	(max)
Advisory services	250 ¹	€1.00	€9.00	€250	€2,250
Financial access	73 ²	€3.00	€14.00	€219	€1,022
Market linkage	73 ²	€3.00	€50.00	€219	€3,650
Supply chain management	73 ²	€0.50	€9.00	€37	€657
Total (assuming no digital constraints)				€725	€7,579
Total factoring in connectivity constraints					
Conservative scenario: (39% of smallholder farmers have mobile subscriptions) ³				€283	€2,956
Less conservative scenario: (70% of smallholder farmers have access to phone in household) ⁴				€507	€5,305

Notes:

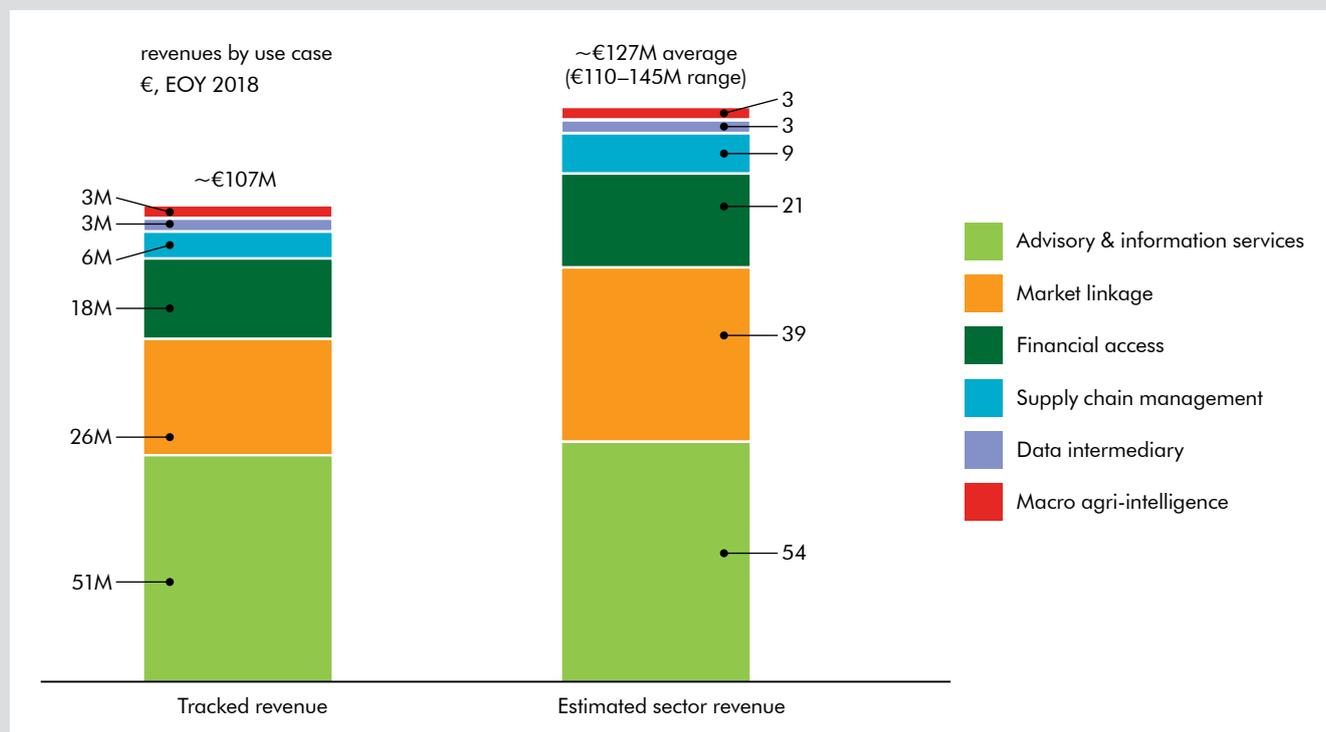
¹ Assumes that every smallholder farmer is part of addressable market for advisory services subscriptions (i.e., possible to have multiple subscribers from family for one farm)

² Assumes that farms or households are a relevant unit for market sizing as multiple subscription for the same product unlikely or impossible

³ Sub-Saharan Africa farmers with unique subscriptions in 2018 (~39%, estimated based on 44% unique subscriber rate in the region and 1.3 ratio of urban to rural connections based on GSMA data)

⁴ Sub-Saharan Africa farmer households owning at least one phone (~70%, estimated based on smallholder farmer survey data from sources such as CGAP smallholder diaries)



Figure 27 **Known and estimated earned revenue by primary use case**

to access, monitor, and manage a large number of farmers for a fee paid by the off-taker.

Overall, we estimate that the total addressable market (TAM) is a maximum of €5.3 billion, depending

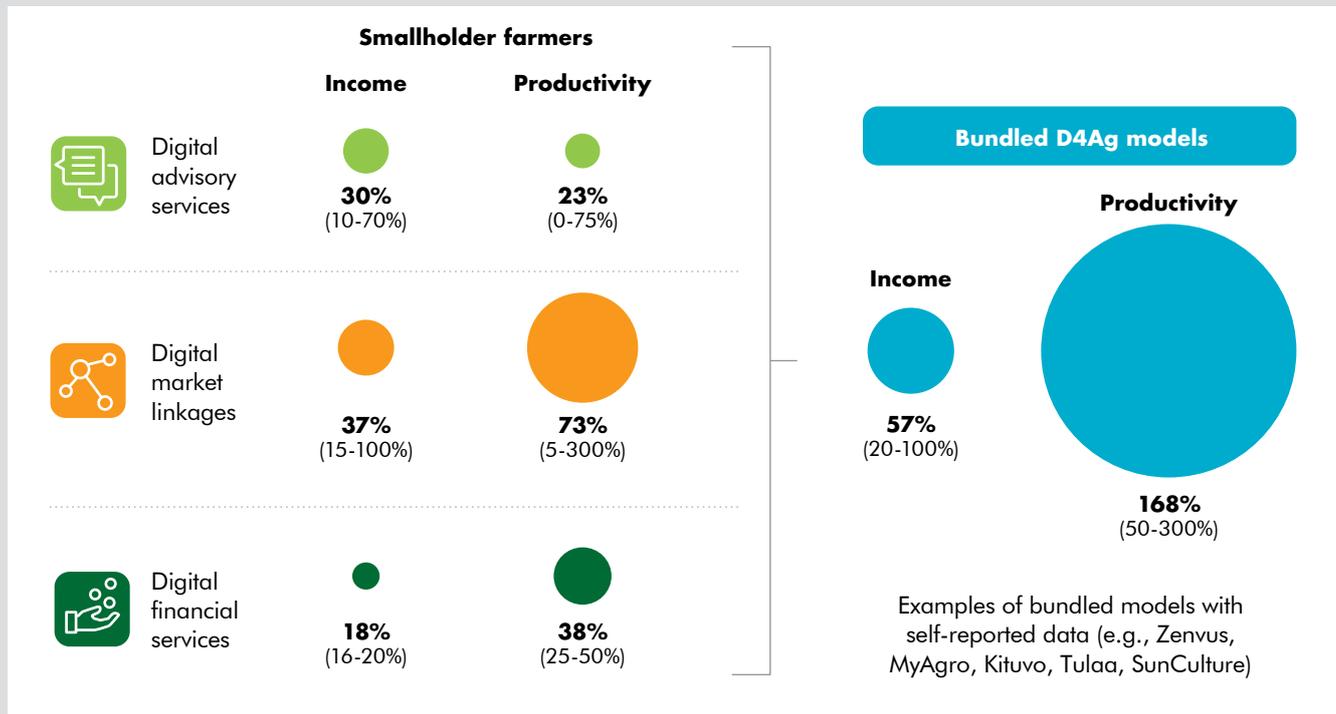
on key assumptions around the number of addressable farmers, average revenue per user (ARPU) by use case (see Figure 26 and additional information on these calculations in Annex 3: Methodology) and constraints around smallholder farmer connectivity.^{283,}

^{284, 285} These ranges are wide primarily for two reasons. First, the ARPU by use case varies significantly: individual enterprises within a use case have widely varying business models and few reliable examples with data points exist today. In our estimates we have therefore applied the highest and lowest ranges based on available estimates from enterprises themselves. Second, there are no reliable estimates of smallholder farmer ownership of mobile phones, and there are multiple ways to arrive at such a figure. As with ARPU, we similarly applied a range of the most

conservative estimates (smallholder farmers with unique mobile phone subscriptions) to less constrained estimates (households owning at least one mobile phone) in order to arrive at a directional estimate.

At the lowest end, the TAM is somewhere between ~€0.3–0.5 billion. These figures apply the lowest end of ARPU for each use case. They are likely to underestimate the TAM because the ARPUs underlying this calculation are likely more representative of the lowest performers in the market, rather than an average. At the highest end, the TAM is approximately €5.3 billion, assuming the highest ARPUs for individual use cases as well as limited constraints around phone ownership (i.e., if a smallholder family owns at least one phone, family members are able to use D4Ag services and are therefore part of the addressable market). These figures are likely to be overestimates; only a handful of companies are achieving the highest end of ARPUs (though in a few cases like market linkages, there are examples of companies



Figure 28 **Quantifying impact – a directional view based on limited data**

*Note: Yield and impact data across ~50 data points cited in literature or captured in USAID ICT4Ag impact database

Source: USAID Impact Database, BMGF Impact Analysis, Dalberg analysis

outperforming our current range) and household ownership of a phone is likely not fully indicative of ability to access D4Ag services. Still, these figures provide useful bounds and suggest that the likely TAM is somewhere between the midpoints of the conservative and less constrained estimates (i.e., \$1.6 billion and \$2.9 billion). As the sector evolves and more data points emerge, the range of estimated values for the addressable market will likely become narrower and more precise.

The D4Ag sector likely generated about \$110–145 million in revenue in 2018,²⁸⁶ a small fraction (6%) of the total addressable market.²⁸⁷ This figure includes commercial enterprises (including financial service providers), NGOs, and MNOs, but excludes governments and agribusinesses. We do not include governments because they typically do not charge users or frame

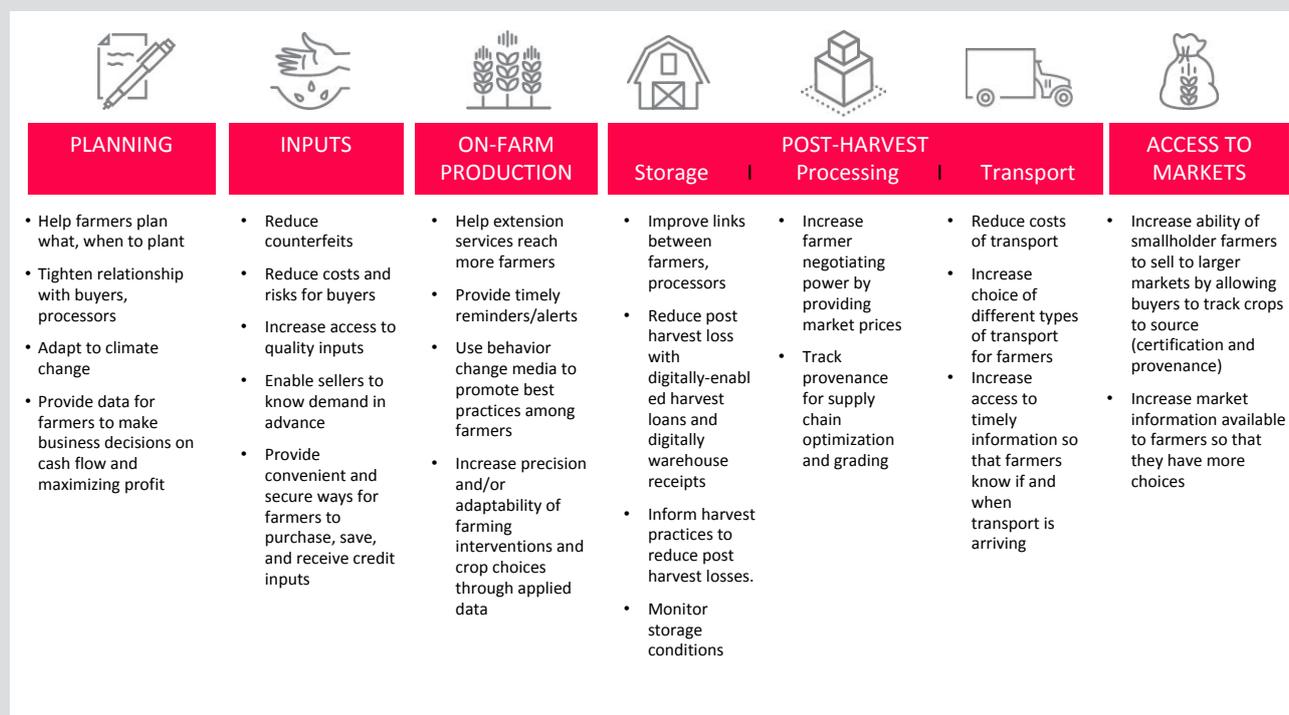
success in terms of revenue – and while D4Ag solutions do reduce agribusinesses' costs and/or increase their revenues, these benefits do not come from user payments – and agribusiness data are difficult to access publicly. Taking the midpoint of the revenue range (\$140 million) and the midpoint of total addressable market (\$2.3 midpoint estimate, \$1.6–2.9 billion range depending on which constraints to connectivity one assumes), we estimate that market penetration today is 6% (between 4–8%).

Evidence of results is emerging though much more is needed

Evidence of D4Ag impact is currently limited. Only a few market leaders currently systematically track the impact of their work. Among those that do, there is little agreement on metrics or methodologies, so comparisons are difficult to make across solutions and



Figure 29 Impact across the smallholder value chain – USAID’s view on the evidence



Source: USAID. 2018. 'How digital tools impact the value chain.'

aggregate impacts are difficult to arrive at. Finally, efforts at tracking impact data not only vary in design and focus, but also vary considerably in robustness. For at least half of the 40-50 impact data points collected for this report across different African D4Ag solutions, the evidence we are left to draw on is based on fairly small samples and/or is self-reported by enterprises. Only a handful of players have applied randomised controlled trials (RCTs) or quasi-experimental evaluation methodologies to measure impact.

Productivity and income are the most universally understood aspects of impact

– but are just two among a wider range of impact types discussed later in this chapter. We define *impact on productivity* as D4Ag increasing farmers' yields, or crop produced per hectare of land. Higher productivity can drive increased revenues, commercialisation, and reduction in the number of agricultural

labourers needed. We define *impact on income* as D4Ag increasing farmers' incomes. Impact on income depends on ease of access to well-priced inputs, fair prices from off-takers, and other factors. Increased income improves quality of life for farmers and their families and helps establish food and nutrition security.

Although conclusive evidence has yet to emerge, some providers have shown that D4Ag can impact the productivity and income of smallholder farmers.

According to self-reported data as well as randomised control trials and other impact studies conducted by D4Ag enterprises, the degree and range of impact differs significantly depending on use case. Advisory services (10–70% income increase, 0–75% yield increase) and financial access (16–20% income increase, 25–50% yield increase) tend to have lower impact on incomes and yields than do market linkages (15–100% income increase, 5–300% yield



increase) (see Figure 29). It is important to note that the sample sizes used to determine these ranges and the average indicated are small; they should be construed as an indication of what is possible, not a definitive representation of the space or use case.

These providers are likely the outliers; the companies that are tracking impact may represent best-case scenarios – and even in these cases it is still difficult to attribute that impact to D4Ag solutions alone (as opposed to, for example, a particularly strong business case, or other aspects of the solution). Anecdotally, these figures are higher than those of purely analogue solutions and are generated at reduced cost.

The span of these ranges indicates that, depending on their business model, even solutions within a single use case can vary significantly in the value they offer farmers. Within advisory services, higher-end solutions are more precise and participatory, but there are insufficient data points to parse out what balance of precision and cost is optimal for farmers. Market linkage solutions that integrate farmers with input providers and off-takers, often using agents and intermediaries, appear to have even greater impacts on yields and income than do advisory

services and FSPs.²⁸⁸ We believe that financial access solutions with different business models and structures would vary in terms of impact as well, but data on impact metrics are too limited to reach more specific conclusions.

Bundling services appears to create more impact. A handful of enterprises that bring together use cases report very high impact numbers (20–100% income impact, 50–300% yield impact). This suggests that, when structured well, combining offerings across use cases could have an additive impact on users.

The impact story is far from complete, but the information we do have is encouraging. Robust evaluations and trustworthy impact metrics are hard to find across the D4Ag space. The sector requires significant investment in capturing impact data if we are to better understand successes and failures to date and in the future. Of critical importance will be user-centric research and design; in-depth case studies of both successful and less successful actors; better evidence of the on-the-ground impact of different use cases and business models, using standardised and rigorous impact metrics; and a better understanding of the specific contributions of digital vs other business model enablers.

Robust evidence is particularly critical as the number of players in the sector explodes and enterprises begin to move from pilot phase to scale – a point at which it is notoriously challenging to maintain strong impact. For whatever impact measurement data do exist, far too little gets captured and published. The CGIAR Big Data in Agriculture initiative has recently launched a process to start to collect this data from the sector, something we believe is overdue and essential for moving the knowledge agenda forward.

We will discuss these impact-related challenges and subsequent recommendations further in Chapters 5 and 6.

CTA



D4Ag’s impacts matter not only for individual smallholder farmers, but also for other agricultural actors – and many agribusinesses are already realising value from D4Ag solutions. The benefits to the broader ecosystem may have a number of indirect positive impacts on smallholder farmers. Digitalisation allows companies to better understand farmers in their value chains (e.g., profiling, monitoring farmer activities) and thus offer them better, more tailored products and services. D4Ag improves internal process efficiencies, as well, by enabling better market aggregation and coordination – thus cutting costs. When information across multiple farmers and catchment areas is combined, companies can know the quantity, quality, and location of the produce available and better manage volume fluctuations for their own use and/or as they take the product to market. Digitally-enabled coordination and supply chain management also reduce the number of agents needed on the ground, which cuts costs. For example, in Southern Africa, large fertiliser companies have begun to use predictive weather data to project farmers’ likely yields, informing decisions about how much fertiliser to provide on credit. In Rwanda, government-led consolidation of localised farming activities, driven by advisory service solutions, has underpinned improved efficiency for off-takers and price leverage for producers.

Recognising the strong potential gains in D4Ag, some agribusinesses have started to invest in building out capabilities in-house, which would allow them to reduce costs and own their valuable proprietary data. For example, Twiga Foods has embedded its entire value chain with digital solutions to create an entirely cashless network.

“

Bundling services appears to create more impact. A handful of enterprises that bring together use cases report very high impact numbers (20–100% income impact, 50–300% yield impact). This suggests that, when structured well, combining offerings across use cases could have an additive impact on users. ”

Digital solutions are also helping governments make more informed decisions and are supporting agricultural planning, albeit more slowly than for agribusinesses.

As an example of how governments are beginning to make use of these data, Ethiopia’s Agricultural Transformation Agency (ATA) has used its highly popular 80-28 system, as well as e-vouchers, to support smallholder farmers while building robust datasets of them, their needs, and government priorities to address those needs. In Rwanda, the government has leveraged digital solutions to consolidate farming activities, facilitating big-picture decisions around commodity pricing, storing, and crop input supply. While these examples are promising, the potential for digital solutions to support macro-level decision making is still largely under-tapped (and completely un-tapped in many countries); we discuss this further in Chapter 4. In the meantime, it is also important to consider the impacts of D4Ag for youth, climate change vulnerability, employment, and women as part of the overall impact story. The next section takes a closer look at the impacts of D4Ag through these lenses.



A DEEPER DIVE INTO HUMAN IMPACTS OF D4AG



Inoussa Maïga, Mediapro



Springboard Nigeria

For a number of reasons, D4Ag will not necessarily have the same impact on all segments of the agricultural labour force or the population more broadly. This report looks particularly at how D4Ag affects young people, climate resilience, employment and women. The next several pages examine how D4Ag could benefit these groups and efforts, the progress and emerging signs of impact so far, and potential risks and challenges.

Youth

D4Ag is seen as a way to attract more youth into agriculture. Over 60% of Africans are under 25 years old. Every year, 10–12 million youth across the continent enter the job market in search of work.²⁸⁹ Vast numbers of young people continue to work in farming in rural areas – agriculture remains the continent’s largest employer – but urban migration among young people is booming, driven by the promise of higher wages and an escape from the drudgery with which farming is often associated. In this context, experts wonder whether D4Ag has the potential to slow or even reverse this trend. As Michael Oluwaghemi, co-founder at LoftyInc Allied Partners and operator of WeHub, explains, D4Ag “puts the ‘sexy’ back in agriculture for our youths. Our farms could become the offices of the future.”²⁹⁰

Youth are more likely than their parents to use D4Ag solutions, but it is hard to prove that this affects their choice of career. Based on our survey data, on average, two-thirds of D4Ag users are under age 35, likely due to the simple fact that younger people tend to be more digitally savvy. As yet we have no conclusive evidence that this means young people are actually more likely to consider working in agriculture. However, the attention governments and donors have paid to youth employment in Africa has increased sharply in recent years. As a result, we expect that new research will help us better understand the continent’s employment challenges and will yield more data on the ways in which the digital transformation of agriculture impacts the sector’s ability to create jobs for young people.

Even without conclusive data, the chances seem good that D4Ag is pulling more young people into agriculture. D4Ag solutions bring clear benefits, some of which are particularly relevant to youth. First, D4Ag makes jobs in the sector more lucrative by increasing yields and profitability. Many digital solutions also make farming work more convenient and less gruelling, and open up opportunities for youth across the value chain, further increasing its appeal. At the same time, funding from all over the world is going to support entrepreneurship in Africa today – much of it with an agricultural tie-in. For example, in Nigeria, Wennovation Hub (WeHub) “empowers [young] African entrepreneurs to solve their immediate socio-economic challenges by leveraging

technology and local resources and build[s] their community and collective networks through collaboration.” WeHub has supported over 6,000 young entrepreneurs and invested in around 30 start-ups.²⁹¹ Much of this space has a strong tech focus, and many of these tech start-ups are run by youth and focused on agriculture. These outfits are also more likely to hire other young people and design products/services that appeal to youth users.

Recognising this potential, donors and incubators are working through D4Ag to bring more youth into agriculture. For example, USAID, Syngenta, IREN and the Toyota Kenya Academy created a forum for youth to present their products to possible investors called the Young Innovators Agribusiness Competition.²⁹² Kosmos Innovation Centre and Reach for Change’s Senegal Start-up Accelerator have provided a half-year of incubation support and \$1,800 in seed funding to five youth-led D4Ag start-ups.²⁹³



Charis UAS

Climate resilience

Climate change will hit Africa harder than most other continents.

Temperatures are rising fast, extreme weather events are expected with increasing frequency, and nearly 70% of Africans work in agriculture – among the most vulnerable sectors to climate change. Farmers will have to cope with changing water cycles and rainfall, more frequent natural disasters, more expensive fuel, and a host of other challenges that have yet to emerge.²⁹⁴ Smallholder farmers bear more risk than others because they depend more on weather-reliant crops and have limited resources to mitigate the stresses climate change will increasingly place on agriculture. The impacts are already being felt. For example, multiple weather shocks in Malawi over the last 20 years have resulted in multiple instances of severe flooding and droughts, including a particularly severe cycle of drought and flooding in 2015. The 2015 weather events resulted in 90,000 hectares of cropped land becoming unusable and the declaration of a national emergency.²⁹⁵

Digital solutions can help farmers become more ‘climate resilient’.

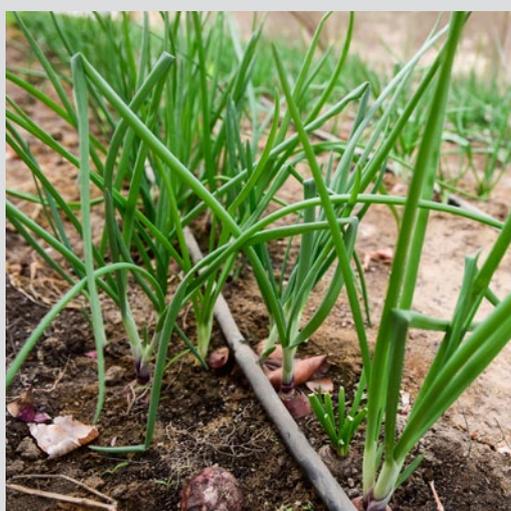
First, D4Ag can help improve the quality of short-term and long-term weather information that farmers receive by increasing the accuracy and the location-specificity of weather forecasts. Specific use cases promise additional benefits – advisory services, for example, can provide farmers with additional guidance that can help them adjust to changing weather patterns. We have also seen digitally-enabled weather insurance help farmers protect themselves financially against more volatile weather. In addition, market linkage solutions could provide farmers access to new, more customised inputs as their land and water resources change. For example, farmers may need fertilisers with more or less nitrogen as soil contents change.²⁹⁶ More broadly, by increasing their productivity, D4Ag



A DEEPER DIVE INTO HUMAN IMPACTS OF D4AG



iDrones Zambia



FAO

can help farmers earn additional income needed to invest in adapting to climate change.

Policymakers and others operating at the macro level could also harness D4Ag to help systems become more climate resilient and even mitigate the effects of climate change. The vast volumes of data that D4Ag solutions can produce will help policy to become more evidence-based. For example, services that track smallholder farmers' use of inputs more precisely and in real time could help policymakers understand how climate change is altering the environment. This would also allow top-down decision makers to better tailor policy and programmes to hyper-local environments. Among the most promising digital technologies for climate change mitigation are satellite imagery and remote sensing to evaluate land use and land cover; there could be opportunities for such solutions to help smallholders in the near future.

Hard evidence of the impact of D4Ag on climate resilience has yet to emerge. As the effects of climate change become more apparent, however, it will likely become easier to observe how digital solutions are enabling farmers to navigate these unprecedented challenges. Already, however, a number of early-mover providers have developed and launched D4Ag solutions that promote climate resilience effectively.

Several players providing farmers with data and coaching on adapting to climate change have experienced success. They either offer farmers more accurate/long-term weather forecast data to help them plan better or offer coaching on a broader set of climate resilience techniques. In many cases, these players combine data from a wide range of sources (satellite data, weather stations, GPS, etc.) in order to improve the quality of forecasts. Standout examples include the Grameen Foundation's Community Knowledge Workers (CKWs), who help Ugandan farmers by providing information on weather-specific agronomic techniques, pests, functioning markets and storage facilities. Digital technologies support CKWs in the form of an online monitoring system and smartphones with relevant applications.²⁹⁷ Esoko also sees information dissemination as an important path for climate change adaptation. It sends climate forecasts, agronomic advice and market prices to farmers in Ghana via mobile phones. This pilot programme increased users' productivity by a stunning 90%. Interestingly, this model places more emphasis on human intermediation, as employees train farmers on how to use the solutions – which may in part explain its success.²⁹⁸

Weather insurance can provide a safety net for climate-vulnerable smallholders, although it remains unaffordable for those most at risk.



ACRE Africa, an insurer with partners in Kenya, Rwanda and Tanzania, has developed a suite of products that enable farmers to handle climate risk using a state- and satellite-based weather index, area yield index, hybrid weather index, multi-peril crop insurance (MPCI) and dairy livestock insurance.²⁹⁹ Its success has been attributed to the fact that it bundles insurance with other solutions (e.g., input credit) and sends pay-outs to farmers using mobile money.³⁰⁰

There are still crucial climate data gaps in Sub-Saharan Africa, but the private sector is becoming aware of the opportunities these gaps represent. The quality of data remains far below the standards of most industrialised countries. For example, one major gap in climate-resilience-focused D4Ag is hyper-local weather information. Weather forecast technology is not yet advanced enough to provide the kind of reliable, five-to-seven-day outlook that smallholder farmers need. And even where raw data are available (e.g., from satellites, ground stations), the gap between data and prediction is significant. Yet gaps like these that go unfilled by government present an opportunity to the private sector. Cutting-edge enterprises like aWhere and Ignitia disseminate more accurate local weather information than ever existed before on the continent and continue to invest in R&D to advance this technology. CTA has launched a project in partnership with the International Livestock Research Institute (ILRI) and private insurance companies to promote a market-driven approach to promoting climate resilience in Southern Ethiopia and Northern Kenya.³⁰¹ Meanwhile, Ignitia raised \$988,000 in Series A funding in late 2018.³⁰² Similarly, GSMA has highlighted the opportunity for MNOs to improve their AgriVAS offerings by incorporating weather index insurance products and to invest in location-based services to collect weather monitoring data and offer highly localised services to farmers.³⁰³ As the effects of climate change become more apparent and piloted solutions start to demonstrate impact, we expect climate-related digital solutions to expand rapidly in number.

Employment

It is too early to say for certain, but it looks likely that D4Ag will create more jobs than it will destroy. Evidence for how D4Ag will affect employment is perhaps the least available of any aspect of impact discussed here, likely because of the breadth of the issue and the number of indirect effects that need to be considered. Some commentators argue that D4Ag will create new jobs that will require new roles and the development of new digital skills. Others point out that automation will likely eliminate or reduce a host of familiar roles and occupations. The reality is that both are likely to happen. Without clear evidence to rely on, our hypothesis nonetheless is that D4Ag will likely be a net job creator, perhaps significantly so.



CTA



A DEEPER DIVE INTO HUMAN IMPACTS OF D4AG



Sonita Tossou



CTA

Emerging D4Ag solution providers in Africa have employed tens of thousands and this number appears to be growing. Based on current trends, the number of D4Ag solution providers in Sub-Saharan Africa will continue to rise rapidly. The jobs created by this will more often than not be relatively highly skilled – for example, tech developers and business managers. If a few hundred of these providers are active, and each hires 10–100 employees, tens of thousands of new jobs will have been created.

Many more jobs will be created among the networks of field agents working with these providers. Today, extension worker density in Africa is about 1 to 1,500 farmers. Successful D4Ag solutions, however, often work with a higher ratio of extension workers to farmers, on the order of one field agent for every 200–500 farmers across use cases like advisory services, input/off-take market linkages and financial service intermediation on the ground (e.g., support for informal digital smallholder farmer village savings and lending group). D4Ag solutions are able to substantially reduce farmer-to-field-agent ratios because digital technologies allow for the upskilling and more efficient monitoring and management of young and inexperienced field officers who require less training and are far less expensive than professional agronomists. Beyond reducing the costs of field agents, digital solutions also improve agent profitability or cost-coverage. With the help of digital solutions, such agents generate incremental value for farmers and other value chain intermediaries like input providers, off-takers and FSPs, thereby making it much easier for D4Ag enterprises to retain such agents or for other players to hire them in large numbers. It is also critical to note that such agents are not a replacement for existing African professional agronomists, but more a complementary last-mile human network that supports value chain formalisation on the ground.

If D4Ag solutions were to become ubiquitous in farming across the continent, this would imply between a threefold and sevenfold increase in the number of field agents. In absolute terms, this would mean the creation of hundreds of thousands of jobs.

D4Ag will increase not only the number of jobs but also their quality. Today, just ~7% of smallholders in Africa work in tight value chains. D4Ag can help them enter well-organised value chains that will increase productivity and, by extension, the level and stability of their income. Digital solutions can help achieve this by improving communication and reducing transaction costs. We also see the opportunity for D4Ag to create formal jobs further up the value chain in agriculture processing and manufacturing. As these sectors tend to be higher value-add, this would translate into higher paying jobs for today's farmers.



While these prospects are encouraging, policymakers need to think about groups that will inevitably lose out from this transformation.

There is no doubt that D4Ag will automate significant numbers of people out of jobs. It is important to look not just at the aggregate impact of D4Ag on jobs; there will be winners and losers. If and when D4Ag becomes truly pervasive, we will see a divide between the ‘haves’ and the ‘have-nots’, or those who were left out of the agricultural transformation journey. The ‘have-nots’ may be driven out of farming altogether by consolidation, stricter quality assurance and price competition. We do not expect this to transpire in the short to medium term – most of the D4Ag industry is still trying to develop viable business models that do not rely on grant support. But it is important for policymakers – especially those investing in D4Ag solutions – to keep this in mind as they ramp up their support for D4Ag and form their visions for the future of agriculture in Africa.



Filippo Brasco, FAO

Women

D4Ag solutions, in theory, have the potential to be transformative for women. Most women (60%) working in Sub-Saharan Africa are employed by the agriculture sector.³⁰⁴ They play leading roles across the agricultural sector as buyers (e.g., in the pineapple value chain in Ghana) and local processors (e.g., as members of Sooretul, an e-commerce platform in Senegal). As with men, digital solutions can increase incomes and yields for women farmers by improving

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Antonello Proto, FAO

agronomic practices, connecting them to markets, and providing credit. But D4Ag offers an additional value that is particularly relevant to women. Due to social norms, many women across the continent are largely confined to their homes. Digital tools like advisory services and market linkage can allow them to access products and services despite this restriction. In doing so, these tools have the potential to increase women's ability to organise and work collectively – one of the most significant drivers of women's empowerment.

However, this potential has yet to be realised. Few D4Ag users are women. Enterprises surveyed report that women comprise 25% of their user base, which is consistent with data from large solutions, and indicates lower reach to women. Moreover, a large share of respondents (57%) did not feature reaching women in their top priorities.

A number of factors contribute to the gender disparity in D4Ag engagement – among them, the underlying gender gap in digital access. Women in Sub-Saharan Africa are 15% less likely to own a mobile phone and 41% less likely to use mobile internet than are men.³⁰⁵ Given that the vast majority of solutions require one or both of these, it is much harder for enterprises to reach women. Reports suggest that the main barriers to female mobile engagement in developing countries are affordability, literacy and skills, safety and security and relevance.³⁰⁶ Yet, providers in Ethiopia, for example, have shown how to work around low digital literacy levels or internet access (see Ethiopia case study in Annex); similar principles could be applied elsewhere to reach more women.

On the supply side, businesses, donors and governments appear to view a specific focus on engaging women as too great a challenge given the barriers to engaging any farmer in D4Ag solutions. Today, D4Ag solutions primarily reach what providers consider the lowest-hanging fruit – (male) farmers in tight value chains. Most enterprises and initiatives fail to prioritise outreach to women and other marginalised segments – and, unsurprisingly, fail to reach them in significant numbers.

To address the gender gap in D4Ag, the entire sector needs to make women a priority. This will require mainstreaming gender in D4Ag initiatives by building gender concerns into donor programming and enterprise solution design. It will also require advocacy to ensure that gender becomes a funding priority.

Industry players can take steps to make it easier to work with women – starting with more inclusive data and solution design. Gender-disaggregated data remain sparse, which hinders problem identification



and trends analysis with respect to women's empowerment in agriculture. For example, Technoserve's Coffee Initiative began collecting data at the individual – instead of the household – level in order to more accurately track training attendance and coffee tree ownership by gender. This was one of multiple measures that may have contributed to increasing female participation in the programme from 6% to 42%.³⁰⁷ As providers then move into solution design, more effort is also needed to involve women users in this process. Rapid prototyping and testing should help ensure that D4Ag solutions are responsive to women's needs. Many of the most active players in D4Ag have applied this to various elements of their businesses targeting women. For example, MyAgro recognised that women farmers typically have smaller land plots and less liquidity than men, and began selling inputs in smaller batches for crops that women typically grow.³⁰⁸

Implementation decisions are also crucial. Other agriculture operators in Africa have demonstrated the imperative of disseminating information and products in safe, convenient and inclusive locations. For example, the Wakulima Tea Company in Tanzania developed 30-minute trainings about application of inputs including fertiliser, held while farmers wait for tea collection trucks; this increased attendance, particularly for women, who perform 70% of tea harvesting. Having gender-diverse programme representatives also matters. A World Bank and International Food Policy Research Institute (IFPRI) study found that female extension agents are more likely to serve female farmers than are male agents (the ratio of women to men was 1.30 for female agents and 0.53 for male agents).³⁰⁹

MyAgro's wider work stands out as an exemplar of how to build a strong base of women users. MyAgro is a mobile layaway programme in Mali and Senegal that equips farmers to buy seeds, fertiliser and training packages. In a short period, it has demonstrated impressive impact by spurring 50–100% increases in harvest yields and □108–334 additional income per farmer. It has also managed to build a user base that is 60% women. MyAgro attributes this achievement to a number of factors: (1) it involves women in its design phases, particularly for products used in the types of farming dominated by women (e.g., peanut farming, or farming on plots smaller than three hectares); (2) it offers smaller seed and fertiliser packets and mobile layaway options, which benefit women, who are more likely to be cash poor; (3) it disseminates information and products through women-dominated village savings and loan associations (VSLAs); (4) it develops village-level distribution centres to work around women's mobility constraints; (5) it focuses explicitly on recruiting female field agents; and (6) perhaps most importantly, it also tracks the impact of these efforts by collecting and analysing gender-disaggregated data.³¹⁰



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WHERE WE ARE HEADED



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We are entering a new phase of more powerful and more capable D4Ag solutions, fuelled by the power of data and ongoing business model innovation. We will see better products, underlying improvements in D4Ag infrastructure, greater investments and many new players. Within three years, the sector could approach 60–100 million registered smallholder farmers and generate annual revenues of €260–380 million.³¹¹

Over the next 3–5 years, we expect to see five major trends in the African D4Ag space:

- 1 Accelerated business model innovation with an increased focus on solutions that formalise smallholder value chains** including D4Ag market linkage services and bundled services, D4Ag ‘super platforms’, and agriculture payment digitalisation initiatives, which will deliver more value to smallholder farmers, agribusiness, and FSPs, and lead to **more attractive D4Ag sector economics**
- 2 Growth in the availability, affordability and use of valuable agriculture data at scale** (e.g., remote sensing and farmer data) and the corresponding growth in sector data analytics capacity to deliver more precise, real-time and impactful D4Ag solutions to the market
- 3 Increased adoption and use of innovative technologies for D4Ag (e.g., remote sensing, diagnostic, IoT sensors), several of which will move beyond experimental pilots to scale**, contributing to the data revolution highlighted above, and also unlocking new business models and impact opportunities
- 4 Increased Africa D4Ag investment by tech VC investors and large commercial players** including big



technology companies, MNOs and agribusinesses and, in parallel, growing investment from philanthropic funders into supporting D4Ag infrastructure public goods (e.g., national-level agronomic data collection, weather and pest surveillance, farmer registries)

- 5 Continued improvement in D4Ag enablers, setting the stage for much more dramatic agriculture digitalisation progress in the longer (5–10 year) time frame**, including growth in connectivity and phone access, expansion of digital payments and digital ID systems and the continued growth and maturation of Africa’s D4Ag incubation and investment ecosystems.

Taken cumulatively these trends should translate into more impact at both the smallholder farmer and macro-economic levels and, critically, a stronger D4Ag business and impact case for the next decade of agriculture sector digitalisation in Sub-Saharan Africa. At the same time (as noted in the discussion below and in Chapter 5 of this report), ensuring and sustaining the positive evolution of the D4Ag sector will require a concerted focus on addressing systemic challenges to D4Ag scale-up and managing emerging risks.

Accelerated D4Ag business model innovation will transform the D4Ag landscape

All D4Ag use cases will see rapid growth in the next few years, but the relative emphasis of the sector will continue shifting toward digital solutions that aggregate and formalise smallholder value chains. We project a clear pivot of business model innovation and sector investments to digitally-enabled market formalisation and aggregation solutions, particularly those that utilise digital tools to support and supplement human agent networks

“Data capture continues to get better, faster and cheaper, which has led to a growing wealth of available information.”

at the last mile for smallholder farmer market linkages, mechanisation, logistics and financial service delivery.³¹²

This pivot, which is already underway, is the result of several interrelated business model insights – highlighted in Chapters 2 and 3 of this report and recapped here – reached by leading D4Ag sector actors and experts. These lessons are informing where and how entrepreneurs, commercial investors and donors are allocating their resources for the next phase of the D4Ag sector’s growth.

The first of these insights is that **D4Ag solutions that focus primarily on data collection and the delivery of information and advisory services are important but insufficient.** On their own, information and advisory services are unable to maximise farmer impact in the absence of parallel and closely linked systems that ensure farmers’ access to inputs, markets and finance.

In addition, solutions narrowly focused on information and advice delivery are highly constrained in their economics due to the limited willingness of farmers and other smallholder farmer value chain actors to pay for advice and information. The willingness to pay is not zero and is growing over time, but the economic value that can be generated per farmer (e.g., via farmer fees, data monetisation or B2B payments by agribusiness) is still insufficient – and will remain so for the foreseeable future – to sustain high margins in most contexts. Such economics are, therefore, typically inadequate to provide for national or region-wide scale-up of digital advisory and information solutions without substantial ongoing donor and government subsidies.³¹³



Looking forward, this does not mean that digital advisory and information solutions will no longer be in favour – rather, the number of solutions with an advisory services component and the reach of such solutions will continue to grow quickly. Large-scale public (e.g., Ethiopia 80-28) and donor-funded (e.g., Digital Green, PAD) digital advisory and information services will grow and remain important as generators of essential public goods. However, we predict that ‘pure play’ advisory solution models among commercially-minded D4Ag enterprises will become far less common over the next few years.

Commercial D4Ag advisory solutions will broaden their mandate by combining the advisory service value proposition with digital market linkages (input, mechanisation and off-take linkage services). They will either do this directly by incubating market linkage solutions in-house to augment or sit alongside the advisory product (e.g., the path taken by Esoko, Farmerline and Digital Green) or via third-party partners with whom they will share value. In line with this trend, we expect that the majority of D4Ag solutions in 3–5 years will primarily focus on market linkages, with

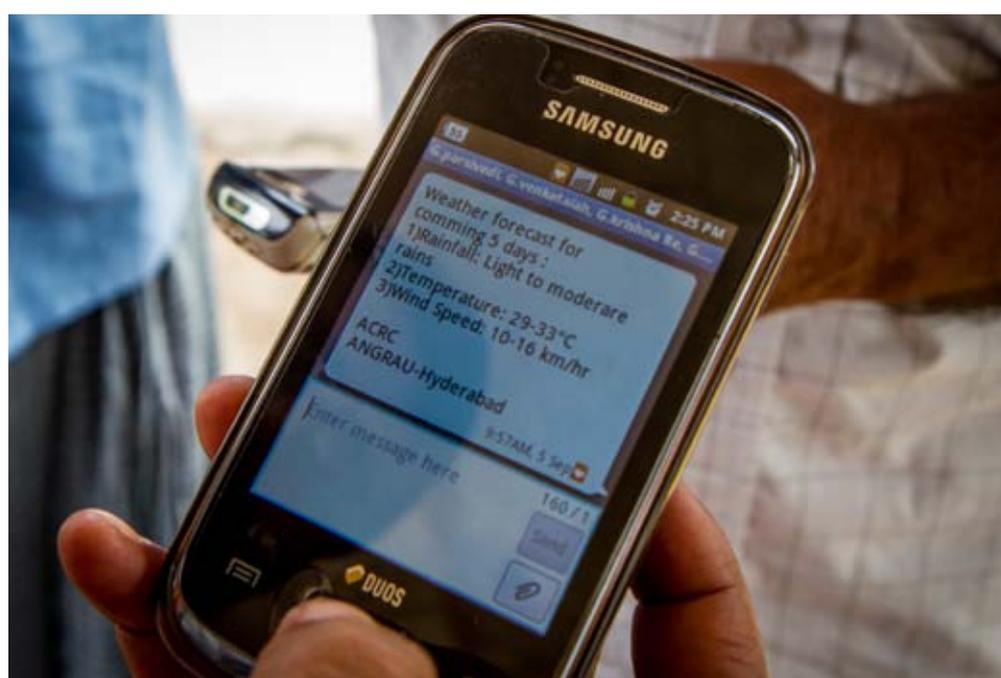
advisory services being a standard component, but typically not one that is monetised or that is essential to the business model’s viability.

There will still be a continued niche for specialised digital advisory enterprises (e.g., for weather data, pest and disease data) who provide B2B information and/or capacity-building services to other D4Ag enterprises, but these will be relatively few in number compared to market linkage solutions.

The second related observation concerning D4Ag business models recognises the value – in terms of both D4Ag impact and economics – of bundling solutions.³¹⁴ Incipient evidence suggests that breakthrough impacts on farmers (>50% increases in incomes, >100% growth in yields) are possible with the help of D4Ag solutions. However, results like these typically require a holistic approach to serving the needs of smallholder farmers by providing digitally-enabled market linkages, advisory services and financial services.³¹⁵

From a business economics perspective, aside from the increased upfront complexity and cost of setting up such solutions, bundled solutions are also uniquely attractive. The key drivers

Fiondella, IRI/CAFS



for improved profitability and scalability of bundled solutions include costs savings due to operational synergies and, more importantly, increasing willingness on the part of farmers to pay for those bundled products that can generate instant economic value – which can take the form of lower input costs or higher, more guaranteed off-take prices alongside the harder to quantify long-term effects of improved farmer productivity and resilience through better practices (which farmers are often unwilling to pay for in the near term).

The most immediate implication over the next few years will be the rise of bundled D4Ag ‘super platform’ solutions as the most common architecture for D4Ag service delivery. The idea of bundling to enhance D4Ag solution impacts and economics is not new. It has informed, for instance, several phases of Mercy Corps’ AgriFin Accelerate programme for the past seven years, starting with bundles of finance and advisory services in a handful of country pilots and broadening to much broader commercial concepts exemplified by Safaricom’s DigiFarm. What *is* new today are the improved and still evolving ideas about *how* to make such models work and, as discussed in depth in Chapter 2, the resulting emergence of D4Ag ‘super platforms’ as a distinct category of D4Ag solutions.

We foresee a proliferation of D4Ag super platform solutions – many at national or value-chain levels – competing with each other, likely with multiple successful players and models emerging in the interim. We predict that the D4Ag super platform model will become the dominant approach in the sector in just a few years, but this does not necessarily mean that the sector will be dominated by a few big unitary commercial digital agriculture platform providers. That is one possible outcome, but an improbable one given the diversity of sector needs. In the longer term (5–10 years), a progressive winnowing and consolidation of solutions is likely, but with Sub-Saharan



Georgina Smith, CIAT

Africa’s myriad policy regimes, value chains and cross-border trade and logistics challenges, a winner-take-all approach for D4Ag platforms is unlikely for the foreseeable future.

The most likely scenario in the next few years is a complex ecosystem of competing and sometimes collaborating super platforms: commercial providers with proprietary, custom-built digital platforms that formalise loose value chains via direct agent market integration models (e.g., Tulaa, Twiga, One Acre Farm), micro-entrepreneur platform models (e.g., Kuza), farmer hubs (e.g., Multiservices Agricole in Senegal), bank platforms (e.g., KCB MobiGrow), value chain management solutions designed for agribusiness (e.g., SAP Rural Sourcing Platform, Olam’s in-house digital stack), government-affiliated or -led platforms (e.g., Smart Nkunganire System in Rwanda), solutions from different specialised D4Ag vendors bundled under common super platform commercial brands and farmer interfaces (e.g., Safaricom’s DigiFarm), families of inter-linked digital solutions or enterprises (e.g., Farmerlink, Esoko and – at the very large end of that scale – Alibaba’s Rural Taobao



system in China) and, finally, looser consortia models, such as the Digital Green-led digital agriculture consortium and related initiatives in Ethiopia, which embrace a more open digital agriculture ecosystem but link independent players together via a common mission, common distribution channels and common application programming interfaces (APIs) to ensure the delivery of holistic solutions to farmers.

Another important insight for the future of D4Ag business models is that transformational impact on smallholders requires digitally-enabled human networks, not *just* purely digital solutions. Human networks consisting of last-mile agents or ‘field forces’ of various types (e.g., agriculture extension officers, digital finance agents, market linkage agents, advisory micro-entrepreneurs, ‘lead farmers’) have been a feature of D4Ag solutions for years (roughly 25–35% of solutions in our database feature agents in some way),³¹⁶ but much of the energy in the African D4Ag sector in the past decade has been focused on the 65–75% of solutions that are direct-to-farmer via SMS, USSD, IVR channels or, more recently, smartphone applications. This focus has been unsurprising as virtual, i.e., ‘pure digital’ models are cheaper to deploy.

Our interviews with sector experts repeatedly highlighted that purely digital D4Ag solutions

– which we do believe have a role to play and will continue to be important – are unable to match the impact of hybrid models due to the familiar barriers of connectivity in the field, digital literacy, farmer trust in digital content and the difficulty of localising content – all issues where human intermediation can help.

For these reasons and others, many sector experts have concluded in recent years that, while direct-to-farmer D4Ag solutions are an important supplemental or ancillary channel for smallholder farmer engagement, for maximal impact and commercial sustainability – in the words of a recent D4Ag business model review by the Syngenta Foundation, a funder of several such models – “field forces [will and must] remain an essential actor in disseminating and embedding digital agriculture solutions” on the ground.³¹⁷

We believe that D4Ag hybrid ‘digital + human’ business models will become much more common for less formal agriculture value chains in Africa.³¹⁸

The logic of sector impact and sector economics will push D4Ag super platform players inexorably in this direction given the lack of existing last-mile agent forces needed to support digitally-enabled market linkage and logistics operations.

One well-trodden pathway to greater integration of human and digital tools will

Georgina Smith, CIAT





continue to be D4Ag enterprise partnerships with existing third-party agent field force organisations to digitalise how such organisations interact with their smallholder farmers (e.g., One Acre Fund extending digital tools to its agents or Digital Green providing a digital overlay for existing national extension agents). The costs of agents in such models are not born by the D4Ag solution, but by third parties. In most cases, however, such third-party organisations simply do not exist for informal agricultural value chains, and other alternatives are needed.

More novel and promising from an impact standpoint are approaches that involve D4Ag players building their own agent field forces, salaried or commission-based, alongside their digital platforms (e.g., myAgro, Tulaa, Twiga, DigiFarm) or using a digital platform as a tool for recruiting, training, capacitating and managing agricultural micro-entrepreneurs in the field (e.g., Kuza). Such models have rightly been seen as more costly and operationally complex than purely digital solutions. When considered in light of the impact potential and sustainability of hybrid models, however, the barriers to integrating human agents (often fairly low-wage-earning youth who can be upskilled and managed via digital tools) are likely more easily surmounted than what is commonly believed, leading to a high return on investment.³¹⁹

In terms of scalability, such models do require more upfront investment and present greater risks, but these are risks that should be quantifiable and manageable for commercial investors as the evidence for hybrid business models accrues over time. Large corporations may be willing to take on such bets for the same long-term, profit-driven reasons that Alibaba in China is investing into Rural Taobao's last-mile infrastructure of stores and agents (60,000 agents today, with plans to expand to more than 300,000 agents over the next few years).³²⁰ Donors and governments, for their part, should have a strong interest in supporting and de-risking such models, given that they function as direct rural job creation engines.

The final D4Ag business model trend that we believe will be notable in the next few years is an increased focus on agriculture payment digitalisation as an entry point for D4Ag solutions. There is growing recognition today that expanding digital payments and building responsible digital payments ecosystems are fundamental to creating a more productive and sustainable agricultural sector.³²¹

By enabling farmers to receive compensation, transparently and securely for their crops, digital payments allow them to save money and reinvest it in their agricultural activities. For agribusinesses, digital payments generate

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the benefits of security and speed, as well as serving as an entry point into broader digitalised supply chain relationships with smallholders that can generate marketing upside, improve product quality/traceability or generate other operational efficiencies.

The GSMA mAgri team has estimated that the potential market for agricultural payment digitalisation is already substantial and likely to grow quickly. By 2020, the potential value of formal procurement payments to farmers in Africa will be ~€300 million annually, of which only 5–10% is captured via payments digitalisation today³²² – a major opportunity for MNOs on the continent. In addition to the revenue potential, GSMA has assessed that “digitising agricultural payments could generate measurable indirect benefits for mobile operators related to the acquisition of new mobile money users, increasing loyalty, increasing volume of transactions and overall activity on mobile money accounts to support a sustainable agent network.”³²³

In the past few years, players like GSMA and the Better Than Cash Alliance, as well as corporations like MasterCard, have focused

substantial energy on supporting agriculture payment digitisation, with a primary focus on formal agribusiness procurement from highly commercial value chains like cocoa in West Africa.

Our interviews and desk research suggest that agriculture payment digitisation initiatives will continue to increase in scale and ambition in the next few years. Building off existing pilots with GSMA and others, MNOs have announced an increased number of agriculture payment digitisation projects and partnerships in 2018–2019. The launch of the new **GSMA Innovation Fund for Digitisation of Agricultural Value Chains** as this report was going to press will likely add further momentum to such initiatives. Development banks like the African Development Bank (AfDB) and the World Bank are embracing the payment digitisation opportunity for priority geographies (e.g., AfDB’s Togo smallholder payment digitisation project).

Even in less formal value chains, payment digitisation is increasingly becoming a standard feature of D4Ag super platform projects, such



as MasterCard Farmer Network, DigiFarm and KCB MobiGrow's work in East Africa, as well as smaller-scale D4Ag platforms like Tulaa and Twiga. Organisations are already seeing results and that will likely add further impetus to the digitisation movement. One Acre Farm, for example, has moved aggressively to digitise loan payments with its 800,000 farmers and, based on early results in a few geographies, has reported reductions in payment losses and collection costs (of 80%), increases in operational efficiency (approximately ~50% less time spent by agents on payments collection) and higher farmer satisfaction relative to cash-based loan payments.³²⁴

While we cannot predict what share of farmer payments will be digitised and by when based on the data available, it is clear that payment digitisation is on its way to becoming a standard feature of D4Ag solutions and interventions.

Vastly larger data volumes and growing data analytics capabilities will result in more impactful D4Ag solutions

D4Ag solutions will increasingly use cutting-edge technologies – fuelled by new sources of data and improved analytical capabilities – to increase their value proposition. This will enhance the precision and relevance of D4Ag solutions, even as they become easier for farmers to access and use. We have seen signs of this trend in our research; over one-third of the respondents to the CTA-Dalberg survey already use at least one form of advanced technology – defined here as drones, augmented/virtual reality, blockchains, machine learning, the internet of things (IoT), big data, artificial intelligence/machine learning, and voice activated technology.³²⁵ Nearly **60% of respondents expect to integrate new technologies over the next three years, the most popular of**

which are IoT, blockchains and machine learning.³²⁶

As discussed in depth in our overview of emerging D4Ag solutions in Chapter 2, we already saw many examples of how sector actors are making use of these data to enable more tailored, precise, real-time recommendations for farmers; give financial service providers the ability to better assess and control risks; and provide valuable insights into smallholder supply chain needs and opportunities for agribusinesses.

While we are excited about the promise of advanced technologies and the growth in data, many technologies (e.g., drones, field sensors) will likely remain in the experimentation phase in the African smallholder farming context for years to come and do not yet have fully settled business models, or at least not yet at scale. It is therefore important, as D4Ag actors experiment with these technologies, that they continue to capture the evidence needed to build the business and impact cases such as technology investments.

We are already seeing an explosion in raw data capture from a range of sources, yet the agriculture data ecosystem remains fragmented. The sheer amount of data collected has increased exponentially.³²⁷ This includes farmer data, soil/land/crop data, and water and climate

Aurora Photos, Alamy



data. The trend is explained in part by the ubiquity of mobile phones (e.g., mobile surveys), but a number of other technologies facilitate agriculture-specific data capture at even greater scale and lower cost – namely, drones, sensors, and satellites.

The data capture from these sources continues to get better, faster, and cheaper, which has led to a growing wealth of available information for both D4Ag intermediaries and farmer end-users. However, despite the growing volume and promise of data, we are still seeing a very fragmented data ecosystem, with many valuable datasets – including much of the data from the public agronomy research community at national and regional levels – locked in organisational silos, not fully digitised, or embedded in proprietary systems owned by financial institutions and agribusinesses.

Sector actors have started to recognise the importance of aggregating data.

These is a growing focus in the sector, led by open agriculture data initiatives from organisations like GODAN and the Open Data Institute (ODI), on ways to ensure that whatever data are captured are stored in an accessible, usable format, and are employed by a broad range of players to improve farmers lives.³²⁸ On a technical level, cloud storage and big data analytics tools facilitate the low-cost storage and aggregation of data in ways that allow others to easily access them and use

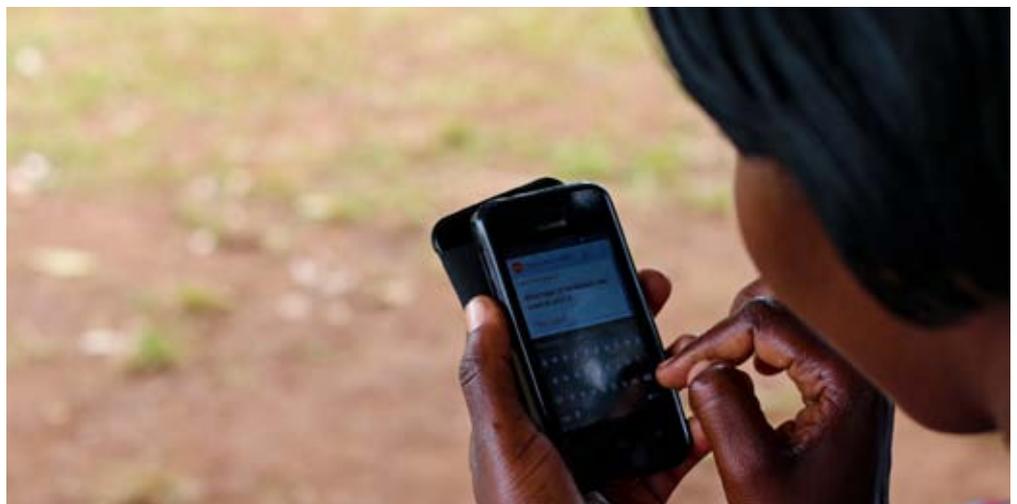
them to generate powerful insights. On a more institutional and policy level, it is becoming increasingly clear that data aggregation is only possible with better defined data regulations and innovative data-sharing business models; progress on both of these fronts is at an early stage.

Strong data analytics capacity – essential in deriving insightful recommendations for farmers from increased data volumes – is developing rapidly but currently lags behind the pace of data generation and capture.

Data analytics and machine learning – two methods by which to leverage these raw data – are in more experimental stages but are quickly improving. There are many forms of data analytics, each of which serves a distinct purpose: descriptive, diagnostic, predictive, prescriptive or cognitive.³²⁹ A handful of agriculture sector actors have begun to experiment with integrating those capabilities into their businesses. The most common models to date have involved specialist agriculture data analytics vendors who collect, analyse, and sell data to interested parties, or in-house teams that accumulate data from other places.³³⁰

The focus for many players over the next three years will be on continuing to improve the quality of data capture and then developing meaningful, actionable insights from these data sets. Big data has

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an important role to play here; we expect the ‘winners’ to be those who are able to combine the various datasets in the most meaningful way and package the insights so that they resonate with farmers.³³¹ Machine learning will be an important tool for accelerating this process. As algorithms learn and improve, they can have increased relevance and power for specific enterprises and farmers.

However, not every organisation will have the financial and human resources to follow this path. The use of data – and especially the more advanced technologies around data – requires specific skill sets and sufficient resources to invest. Many players today lack one or both of these. We expect that many D4Ag organisations will try to embrace the potential of data, but only a small percentage (though impossible to quantify) will be able to take advantage of it. Thus, in the coming years, we may also see some greater consolidation within the sector as data analytics leaders outcompete their slower-moving rivals.

Successful solutions will be those that can ‘crack the code’ on how best to use data.³³² These solutions will be able to integrate the many sources and types of data in a compelling way to best deliver value to the farmer. The data-informed output must be insightful, precise, simple to use, and – most importantly – truly address the pain points that farmers care about most. This ‘data revolution’

should lead to markedly better products for B2B and B2C users, as they will be specifically and precisely designed to meet these users’ needs.

This data-driven approach will push past some of the limitations of today’s solutions in order to target what people want. Data-informed solutions will be designed around a deep understanding of their users’ behaviours and needs; as such, they should encourage higher uptake and create real impact for farmers. Eighty per cent of survey respondents indicated that they have tailored or plan to further tailor their products for smallholder farmers. Moreover, the ongoing collection of data and use of pattern-recognition and machine learning tools should enable D4Ag solution providers to recalibrate their solutions based on user results and the ability to diagnose what is and is not working.

This ‘data revolution’ will not only allow for improved user information and feedback loops but will also extend the offerings that solutions can provide smallholders. For example, chatbots that share photos with farmers and voice-based solutions that allow farmers to hear advice rather than read it have begun to overcome the challenges of illiteracy and low connectivity. Additionally, data-driven solutions can provide smallholders with critical farm guidance with an unprecedented level



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of precision, localisation, and customisation. Similarly, drone technology is being used to create highly accurate maps that can be used for mapping land boundaries with a range of possible uses, such as land titling and clarifying land ownership.³³³ These and other methods should further bridge the gap between reach and impact.

The increased use of data in agriculture is not, however, without risks. To begin with, many of the technologies in question (e.g., machine learning, data analytics) leverage similarities. In other words, they rigorously use data from one case to predict another. This reliance on commonality could present a challenge in a sector as massive and varied as agriculture.³³⁴ The agricultural sector in Africa comprises nearly 70% of the workforce and differs widely from place to place in crop, climate, human context, farmer characteristics, etc.³³⁵

Moreover, when it comes to data analytics, and artificial intelligence especially, there is a danger of reinforcing existing biases. As one illustration, today's solutions currently reach very few women or other marginalised groups. The algorithms in question are based on inputs of historical data. Since all inputs

into these systems would be solutions skewed towards men, their outputs would reflect the same biases. These technologies also come with other important risks and concerns around data governance and consumer protection (including privacy and informed consent). In Chapter 5, we discuss how governments, donors and investors can ensure that these technologies are adopted in an effective and appropriate manner.

User design, experience, and understanding must also go hand in hand with such data-based insights. One commonly cited benefit of data analytics is that it “can reduce the amount of direct input needed from the farmer”.³³⁶ But by distancing themselves from farmers, solutions may more easily misrepresent their desires and needs. The balance between data and ground-level knowledge is an important one to strike and will be discussed more later.

Longer time horizons are the key to managing these and other risks. It is critical that players take time to think through the consequences of the models and methods they design before implementation and follow up with rigorous evaluation and adjustment – even if doing so slows down the pace of

FAO



transformation. Moreover, by its very nature the agriculture sector moves more slowly than the technology sector; tech players will need to practice patience and re-orient themselves toward a more long-term approach. Failing to do so will risk entrenching existing issues in the design of new solutions, creating new and unanticipated consequences, and veering away from an *inclusive* agricultural transformation.

Innovative technologies for D4Ag will support the agriculture data revolution and also enable new business models and impact possibilities

Solutions built on emerging technologies – several of which are beginning to move from experimental pilot to scale

– will contribute to this new age of data-driven agriculture by providing new and better sources of data, improved data storage and aggregation, and stronger capabilities of analysing and using this data. IoT helps generate massive amounts of data. Big data makes it possible for the storing, processing, and analysis of this data to arrive at potentially powerful insights. Machine learning allows us to improve solutions on an ongoing basis, building algorithms that understand users even better than we may. Each technology is individually powerful; in combination, they create a virtuous cycle that can generate even more precise and tailored products, pushing the boundaries of what D4Ag can do.

It is important to note that the use of these technologies in Africa is still early and experimental in nature. This is due (in some cases) to the nascency of the technologies themselves, regulatory and policy constraints (e.g., policy constraints on drone operations), the relatively high levels of capital investment required, and the lack of additional skills needed among people designing and using these technologies or trying to adapt them to the African context.



C. Schubert, CCAFS

In the case of the internet of things, for example, we estimate based on the CTA-Dalberg database that in 2019 likely **fewer than 50,000 smallholders in Africa** had a field sensor on their farms and perhaps **several hundred thousand** were starting to experience the benefits of machinery sensors in tractors via Hello Tractor and irrigation pumps via SunCulture.

Likewise, we estimate that across the 30+ smallholder-focused drone start-ups in Africa, only a few hundred thousand hectares of land have been scanned and, likely, **only tens of thousands of African farmers have had their field analysed via drone flyovers** in the past few years. There is a long way to go for these solutions to become mainstream in the sector, but in every single case there are encouraging signs of major investments on the way or new commercial entrants focused on technology integration.

Here we provide a snapshot of each of these technologies and their relevance to agriculture in Sub-Saharan Africa, as well as early examples of their application and a glimpse at their future potential.



NEW TECHNOLOGIES POWERING THE PATH FORWARD



Charlie Pye-Smith, CTA

The internet of things (IoT)

Collecting and transferring vast amounts of data with mobile phones, sensors, drones, and satellites

IoT – a term used to describe the connection of devices to the internet – enables the generation and transfer of massive amounts of data. IoT enables devices that gather data (e.g., sensors, mobile phones, drones, satellites, etc.) to transmit the data they capture over the internet. Importantly, IoT allows one to capture data from a source without being there in person; this ability is the basis of the surge in available data today.

At 30% year-over-year growth in connections since 2015, IoT is growing quickly in Africa.³³⁷ This growth in IoT connections has the potential to help transform agriculture through the use of a range of devices to bring precision farming – historically, a luxury only Western countries could afford – to Africa. Much of this growth is being fuelled by the falling prices of IoT technology. For example, the FarmBeats project has developed a cheap alternative to a drone that can capture farm data from the air. “Tethered Eye” helium balloons act as aerial sensors, collecting images of farm conditions and then refining the data collected by sensors on the ground.³³⁸

IoT devices use a vast array of sensors to capture localised and valuable data to support agriculture in Africa: (i) location sensors that use GPS signals that capture precise latitude and longitude details of individual farms; (ii) soil sensors, which help determine soil properties, pH conditions, nutrient levels, air permeability and moisture levels; (iii) weather stations that use a combination of sensors to capture climatic data including air temperature, soil temperature, wind direction and speed, rainfall and atmospheric pressure; (iv) storage sensors that check gas levels, moisture, and other conditions that could contribute to post-harvest loss;³³⁹ and (v) livestock sensors that measure location, activity, and health metrics like temperature for animals.³⁴⁰

Combined, the insights from these IoT devices can provide farmers in Sub-Saharan Africa with a number of benefits, such as boundary mapping, weather prediction, yield monitoring, disease detection, fertiliser calculations, and harvest predictions. The insights emerging from sensor data are meant to help farmers make better decisions (e.g., concerning input use) – based on localised, customised, and real-time information – that ultimately improve crop quality and result in greater yields. For agribusinesses and FSPs, these insights can be used to tailor marketing activities (e.g., offer more customised fertilisers) or even extend services to farmers that otherwise would not be available – for example,



yield prediction data can give FSPs the comfort they need to offer farmers loans; similarly, weather data can help insurers extend insurance to farmers. For governments, maps with such detailed information can help improve macro-level decision-making and resource allocation. It can also help increase the value of their extension agents on the ground, who can make recommendations based on individual farmers' needs rather than, for instance, relying on outdated, generic soil cards.

We are starting to see some promising signs emerge for each of these use cases. Ujuzi Kilimo, a Kenya-based D4Ag firm that uses soil sensors and data analytics to send highly localised advice to farmers via text message, draws on data from satellites, sensors, institutions, and local weather to “generate insights using machine learning and data analytics.”³⁴¹ Zenvus, based in Nigeria, uses soil data to optimise inputs and drive access to finance; Zenvus is currently making use of the IoT technology in its Smartfarm products to collect vast amounts of soil data from the smallholder farmers it works with. These data both inform the use of fertilisers and pesticides at the farm level and are being sold on a subscription basis to banks to increase lending, insurance, and investments.

There is some emerging evidence that these technologies are creating positive impact on the ground, but they are still too new to make definitive claims. For example, players such as Microsoft FarmBeats, Zenvus, Ujuzi Kilimo and Lentera, which use on-farm sensors, report that farmers receiving advice are able to substantially improve their yields due to improved advice precision. While these advancements are encouraging, they are typically not yet rigorously measured with external validation and robust impact measurement techniques.

IoT for agriculture is still experimental in nature in Sub-Saharan Africa; even with rapidly declining field sensor costs, it will likely take 5–10 years or more before IoT solutions are mainstreamed at any scale. The underlying technologies are still expensive (though rapidly falling in price), devices do not always work (i.e., sensors have often been built for Western markets and have not sufficiently been tailored for local markets), and farmers and actors do not always know how or choose not to implement the insights and recommendations. Furthermore, the growth of IoT, as with much of D4Ag, is uneven and often limited to the usual suspects: Kenya is leading the way on IoT uptake for smallholder farming, and experiments are underway in Ghana, Nigeria, Rwanda, and, to a lesser extent, Senegal.³⁴²



Charlie Pye-Smith, CTA



NEW TECHNOLOGIES POWERING THE PATH FORWARD



CTA

Big data

Bringing large sets of data together to generate deeper insights

Big data allows companies to store, aggregate and analyse large sets of data to generate insights that inform business decisions. Strictly speaking, big data is a term that is used to describe large volumes of data and datasets. Yet it is not the quantity of data that matters so much as the ability to aggregate, store and analyse all these data to generate insights. For the purposes of this discussion, we therefore refer to big data as both the datasets and the processing capabilities.

Applying big data to Sub-Saharan African agriculture can improve farmers' livelihoods and inform better decision-making at the macro level. Big data capabilities are allowing D4Ag actors to generate insights from the vast amounts of data now being generated. Indeed, in many of the examples we described above, big data analytical capabilities are powering enterprises' ability to make use of the data that they are collecting (from, among other sources, IoT connected devices) across all of the use cases we discuss in this report. More broadly, big data is transforming disciplines like genomics, crop breeding, climate modelling, and agronomy. By analysing new datasets in more powerful ways, we can accelerate the development of better responses to some of the most pressing challenges facing Sub-Saharan Africa: climate change, food insecurity, and environmental degradation.³⁴³

Donors and developing country governments have woken up to the imperative of bringing big data to agriculture. In 2018, a coalition including the Food and Agriculture Organization (FAO), the Bill and Melinda Gates Foundation (BMGF), and national governments launched a \$449-million fund to help countries in Sub-Saharan Africa, Latin America, and Asia gather more data on small-scale farmers to help them learn and adopt better farming practices. The work will focus on expanding surveys run by the FAO and the World Bank to gather information on factors like livestock holdings and crop yields.³⁴⁴ CGIAR, a global partnership to advance research into food security, has also set up a platform (known as the CGIAR Platform for Big Data in Agriculture) in order to harness the power of big data for agricultural research. The platform aims to improve the use of big data within the CGIAR system, open up and share data outside the CGIAR system, and help facilitate partnerships to expand the breadth of big data capabilities in agriculture.³⁴⁵



This momentum is supporting the growth of more solutions built on big data. Kilimo Salama (now ACRE Africa), a company launched in 2009 that offers an insurance product for smallholder farmers, is one such example. It is the product of a partnership between the large insurer UAP Insurance, Safaricom, and Syngenta Foundation for Sustainable Agriculture (SFSA). It combines real-time weather data with regional-level historical climate and crop yield data to estimate indemnities more accurately and efficiently. The project has now expanded to other countries in the region (e.g., Rwanda, Tanzania). Evidence suggests that farmers who were clients of ACRE Africa invested 20% more in their operations and generated 16% more income than did those farmers who were not insured.³⁴⁶ CGIAR has also supported several big data tools for farming. For example, in partnership with the International Potato Centre, it launched an online Pest Distribution and Risk Atlas for Africa – an open-access, mobile-accessible resource that combines up-to-date information on major insect threats to crop production with risk maps for each pest and predictions for future climate scenarios.³⁴⁷

But big data analytical capabilities in Africa are still limited. Big data analysis is often conducted by third-party private firms that offer their analytics capabilities to private and public clients. For example, MNOs like Safaricom and lenders such as Central Bank of Africa use firms such as Cignifi and Experian to produce consumer-risk profiles. Human capacity will need to be built (both in-house and among third-party firms) in order to realise the value of the data being collected today (see more in Chapter 6). Another challenge is that existing datasets are often closed. Despite donor-led efforts to create more open data public goods, there is not yet significant momentum around (or use of) these resources.

Greater scale implies more widely shared data. Policymakers and lawmakers will need to make data decisions that are democratic, support the benefits of big data and still protect privacy. As we begin to share data more frequently and widely – between public and private actors and between different countries – laws will need to adapt quickly to ensure that users (in this, case farmers) can (1) consent to how their data are being collected and used; (2) access the information themselves, bearing in mind the digital literacy challenges that exist in many parts of the world; and (3) trust in systems to protect their security and privacy. Achieving these objectives will be significantly more complex than it was before the digitalisation of data, not least because now vastly more stakeholders are involved in collecting, analysing, and using this information.



IFAD



NEW TECHNOLOGIES POWERING THE PATH FORWARD



Charlie Pye-Smith, CTA

Machine learning

Unlocking the predictive capabilities of data by automating learning

Machine learning is the application of artificial intelligence to allow systems to learn and improve themselves without explicit programming. If IoT is enabling the capture of billions of farm-level data points, machine learning is enabling the analysis of these data to improve automatically and continuously. As enterprises capture increasing amounts of data, machine learning can help them automatically improve the level of tailoring and precision of insights for specific smallholder farming segments, value chains, and geographies. There is also hope that machine learning may help solution providers overcome digital literacy challenges without solely relying on extension agents, e.g., through the use of interactive voice response (IVR) systems and chatbots.

Machine learning solutions are currently at an even earlier stage than IoT. The reason is at least twofold. First, machine learning requires thousands of data points for computers to build accurate algorithms, and the system needs to be fed with new data regularly to continue to improve its accuracy. As we discussed above, those data points are just starting to emerge in Africa, so progress in IoT and big data will fuel progress in machine learning. There have been some experiments to test solutions built for other markets (e.g., the US) in Africa, but those solutions have often fared poorly in initial trials and needed more local information before they were sufficiently accurate in the local context. Second, the talent required to build machine learning capabilities is significant (more so, even, than for big data analysis); as we discuss in the next chapter, the IT talent shortage in Africa is already acute. Machine learning also comes with important risks, i.e., because the underlying algorithms themselves may be biased or there may not be sufficient data on a specific segment, machine learning may not always offer the best solutions for specific communities. This can often be hard to notice or correct because the machine learning algorithms are rarely transparent.

A number of machine learning experiments with agriculture are already underway. For example, Apollo Agriculture in Kenya uses agronomic machine learning to deliver customised and immediate advice to smallholder farmers. Farmers are able to call a local hotline and, through a conversation with an intelligent and interactive robotic system, access information about daily market prices, use of fertilisers, and expected crop yield. Even though it is still a challenge to set up an IVR system that is fluent across multiple local languages, the system has already enabled Apollo to improve its service offering in selected



regions of Kenya. Another interesting application of machine learning is WeFarm which uses machine learning and the power of the crowd to source the best answers culled from the platform's network of more than 1.3 million farmers in Kenya and Uganda. Wefarm's network allows small-scale farmers to ask each other questions on anything related to agriculture and then receive bespoke content and ideas in response. Wefarm's machine learning algorithms then match each question to the best suited responder.

Elsewhere in Africa, AI-enabled solutions are helping farmers combat plant pests and disease, likely the most mature application of machine learning in the D4Ag sector at this stage. For example, the app known as Nuru was crafted by taking thousands of photos of infected leaves. After experts diagnosed the diseases, the photos were organised into a database, which was used to train the software using machine learning to recognise the symptoms. The app is user-friendly, and farmers or extension agents simply point their smartphone camera at several cassava leaves and Nuru responds with a diagnosis. It can also work offline, getting around the challenge of limited connectivity facing many farmers. In terms of effectiveness, its developers say that the app is now twice as good at detection as extension workers.³⁴⁸ Similarly, Plantix, by Berlin-based PEAT GmbH, uses neural networks to diagnose plant pests and diseases via image recognition. Plantix's machine learning algorithm detects over 400 plant diseases, pests, and nutritional deficiencies and uses a learning data set of several million plant images crowdsourced from smallholder farmers. The application has over 700,000 users monthly, and is currently primarily India-focused, but already has North Africa pilots and plans for Sub-Saharan Africa entry.³⁴⁹

The growing success and scale of solutions such as Apollo Agriculture, WeFarm, Nuru, and Plantix, helping to draw more resources and attention to machine learning in agriculture. Four of the five innovation grants distributed in 2017 through the CGIAR Platform for Big Data in Agriculture (via its Inspire Challenge) went to machine learning projects, including pest and disease monitoring solutions and improved advisory services. As we explore later in the chapter, big tech players like IBM and Microsoft are also making major investments in machine learning for agriculture.



Mergdata Services



BLOCKCHAIN



Pasko Maksim, Shutterstock

The transparency at the heart of blockchain technology can make systems more efficient, actors more accountable, and products and transactions more traceable – as everyone interacts with a peer-to-peer network that records all transactions and is not controlled by a single actor.³⁵⁰

Optimising for transparency, efficiency, and safety

In the agriculture sector, blockchain can be applied to a wide range of use cases. At the most fundamental level, blockchain can help provide farmers with secure, portable digital identities. Using those digital identities, organisations working with farmers (from non-profits to commercial enterprises) can help create a digital footprint for farmers that includes their transaction history and a registry of their assets. This footprint, in turn, helps farmers prove that they are who they say they are, and opens the door to a range of services (particularly financial services) that they might otherwise be unable to access.

Blockchain technology can also be used to trace the production and transaction journey of agricultural inputs and outputs. This provides more certainty and builds trust at each point of the supply chain, so that farmers can be confident that they are actually receiving the high-quality inputs – like seeds and fertilisers – that they are paying for. Blockchain can also help providers who are serving smallholder farmers. For example, blockchains ensure that every transaction within the supply chain – from the movement of a crate to the payment from buyer to farmer – is tracked.³⁵¹ These data can be used by agribusinesses and others to better understand their supply chains and take action to improve efficiency and effectiveness – ultimately lowering costs.

In addition, Blockchain has the potential to transform support services that farmers rely on, such as banking. For example, by making verification easier, the technology can facilitate lending to farmers, insurance and other financial services.³⁵² At a more systemic level, blockchain could also help to quickly identify the source of disease outbreaks in farming produce. A greater level of transparency would also allow buyers and sellers to work more directly with each other rather than through intermediaries, leading to efficiency savings.

Several promising initiatives are beginning to demonstrate the power of blockchains in agriculture.

Blockchains are being integrated into D4Ag market linkage and supply chain management solutions to improve value chain trust and thus to maximise the uptake and ‘stickiness’ of farmers and other value chain intermediaries on such platforms, while also reducing transaction costs and speed for anyone attempting to monitor, back-trace, and verify underlying transactions.

The most ambitious example of blockchain use in this context is **Cellulant’s Agrikore** product, which aims to register millions of agriculture value chain



intermediaries, such as farmers, agro-dealers, input producers, bankers, logistics companies, and warehouse receipt operators into a single transparent blockchain-based ecosystem. Users can make use of blockchain technology to transact at a low cost and with high levels of trust; in addition, the platform facilitates supply chain logistics management, traceability and access to finance for farmers as all contracts and transactions are recorded in an immutable system.

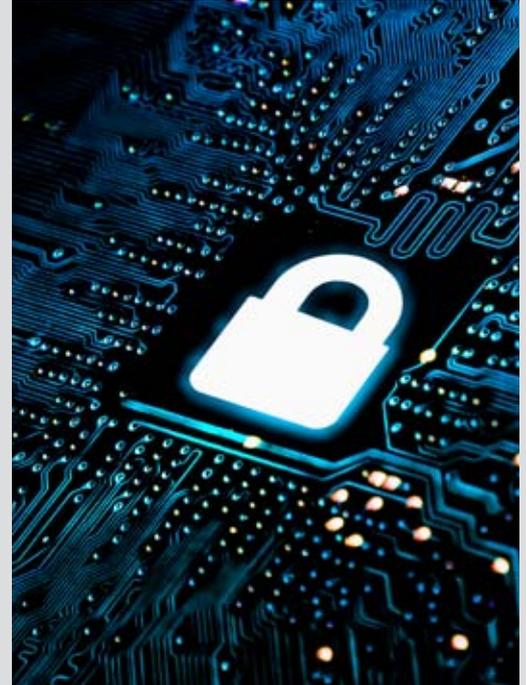
Hello Tractor relies on a blockchain solution, developed in partnership with IBM, to provide a tamper-proof record of demand-side and supply-side processes ranging from tractor booking requests, to order fulfilment, payments for tractor services, distribution of proceeds to the tractor owners on the platform, and invoicing to farmers. The platform thus serves as a blockchain-enabled supply chain, finance, and logistics management ERP system.

Tulaa utilises a blockchain-enabled system to track input and off-take supply chain logistics with its farmers, e.g., using the blockchain to validate hand-offs at key points across different value chain players to prevent agri-input fraud and ensure ultimate product quality.

Finally, the **University Cambridge Institute for Sustainability Leadership** and a corporate consortium recently deployed a solution that uses blockchain to follow the path of tea and wood products from Malawi to Sainsbury and Unilever.³⁵³

Another application for blockchains is to provide farmers with immutable identification. **BanQu**, based on Ethereum and tested in the Democratic Republic of Congo and several other African countries, is one notable example. It allows farmers to use their mobile phones to record their personal information and transaction history, which are then verified by a network of friends, family, and agribusiness partners. **AgriLedger** and **AgUnity** provide unique identities for farmers on their platforms and register individual transactions. This allows farmers to work in an atmosphere of trust with farmer cooperatives while also developing a 'bankable' transaction record that is immutable and can be made accessible to financial institutions with the farmer's permission. In another variation on using blockchains for identification, the Government of Rwanda has teamed up with **Microsoft** and **Wisekey**, a global cybersecurity company, to create digital records of the country's farm land registry that cannot be tampered with.

The most common use of blockchain today in African agriculture is to help facilitate the speed and lower the costs of payments. **Cellulant's Agrikore** was already mentioned in this regard above.



Patyariya, Shutterstock



BLOCKCHAIN



Jim Sabogal

Twiga, another example, is partnering with IBM to use blockchains to manage its loan application process for its retailers and farmers. Blockchain makes the application easier, faster, more transparent and – as a result – somewhat more affordable for counterparties to access financing.

Dodore's Agri-Wallet is a digital wallet and financial tool that creates a business account for farmers on the back of a blockchain platform.³⁵⁴ As farmers earn revenues, they can be paid either through M-Pesa or through blockchain-tracked tokens, which can be used to purchase inputs from vetted vendors who participate in the programme. These tokens and related blockchain verifications are then used as a form of collateral; lenders like Rabobank are willing to provide loans against the tokens in the absence of more traditional collateral.

In the cross-border agriculture payments context, **CropCrowd**, a crowdfarming site, uses a blockchain platform to receive crowdfunding investments and to process payments back to international investors without the need for difficult and costly (or sometimes impossible) currency conversion transactions. Similarly, San Francisco-based Veem is being used by international buyers to pay farmer suppliers in countries across Africa and Asia. The Veem automated platform uses blockchain to convert payments from the source currency into the local currency in more than 80 receiving countries; it cuts payment time in half and reduces payment costs from as high as 12% to approximately 2%.

For blockchain to work in developing countries, data will need to be digitised, standardised, and checked for accuracy. Most data in Africa continue to be paper-based. The trajectory of big data, IoT machine learning, and other innovations will likely determine the extent to which this remains true – and each of these technologies faces its own scale-up challenges. Once data are recorded in the blockchain ledger, they cannot be changed, so it would be essential to avoid the influence of corruption and fraud before this stage. This may prove a formidable challenge in many Sub-Saharan Africa countries. Blockchain's future, then, rests on the ability and willingness of countries to tackle widespread governance challenges.³⁵⁵ Moreover, in order for blockchain to work, everyone in the 'network' must use the same technology, which often comes with verification structures and other auxiliary items.³⁵⁶ This standardisation brings high initial costs.³⁵⁷



Increased investment will come from donors, private investors, and large corporates

Based on current trends, we predict that both donor and private capital flows to D4Ag solution developers and implementers in Africa will accelerate significantly in the next few years.

Current trends in donor and private D4Ag investments suggest a clear upward trajectory; our interviews with key stakeholders were unanimous in supporting this projection of significant increases in funding and investment volumes. Whether such increases will be enough to meet the needs of the D4Ag sector is an open question, however; much depends on the evidence that D4Ag players are able to muster for the impact and business model sustainability of their solutions.

The total amount of ‘needed’ investment is impossible to estimate at this stage given gaps in data and the infancy of D4Ag business models, but the amount is certain to be in the hundreds of millions of euros today and trending toward \square billion the next 3–5 years based on historical trends.³⁵⁸

Furthermore, it is important to distinguish between the funding needs of individual D4Ag players and the need for public good investments into D4Ag infrastructure, which we have not been able to quantify precisely in this report, but which are likely on the order of several billion euros.³⁵⁹ While funders and investors may be able to meet the needs of leading individual African D4Ag enterprises in the coming few years, it is almost certain that there is insufficient funding in the pipeline for D4Ag infrastructure public goods. Rough estimates put this gap at greater than \square billion.³⁶⁰

Donor activity

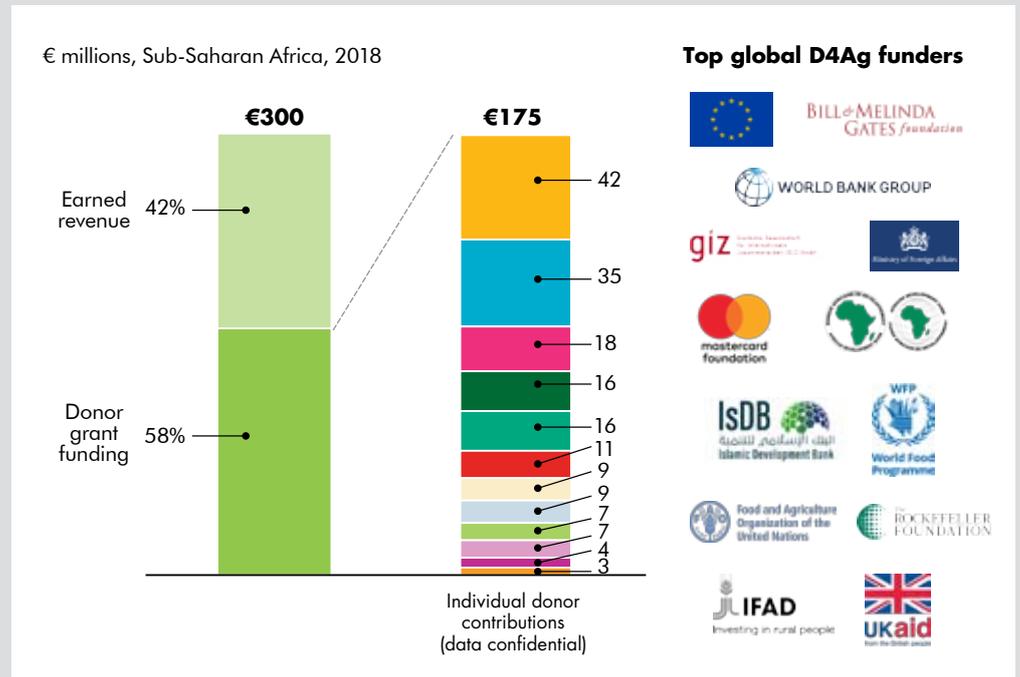
Based on Dalberg’s earlier analysis of D4Ag donor flows for the BMGF, as of 2015–2016, an estimated \square 85–100 million annually in donor money was flowing specifically to D4Ag initiatives in Africa. We estimate that this number grew to \square 75 million by 2018, based on estimated self-reported funding figures collected from top 15 Africa D4Ag funders globally. These estimates exclude broader donor investment in connectivity and ICT access or funding for small digital components (e.g., digital M&E tools, remote sensing costs) of large agriculture projects, a decentralised spending item that could be substantial but for which no data are available.

As can be seen from the figures above (and taking into account the very directional nature of all of such numbers), donor funding for D4Ag appears to have grown by 15–30% annually in the past few years – a pace of growth that, anecdotally, felt accurate to the donors we interviewed given the general rise in attention to D4Ag in the past few years. Using mid-range estimates of donor spending, there were two donors who consistently spent more than \square 20 million annually on the sector, four who spent \square 10–20, six who spent \square 2–10 million and a longer tail of actors who provided D4Ag grants. The specific funding figures have been anonymised at donor request, but the top donors in the sector (to the best of our knowledge) appear in Figure 31.

“ We recently introduced a digital-by-default policy across all our sectors and all our countries. We have asked each project lead to think in terms of digital first when conceptualising a new project, and to thoroughly justify any reason not to choose digital. ”

Representative of a leading donor



Figure 31 **Estimated annual Sub-Saharan Africa D4Ag funding, 2018**

Donors are likely to continue to grow their investments in D4Ag in the near future. All the foundations, development banks and multilateral agencies interviewed suggested that they were likely to increase their D4Ag investments in the coming 3–5 years, but most were unable to provide specific funding commitments or targets as so many donor D4Ag strategies were still in flux at the time of this report's completion.³⁶¹ In most cases, they were looking to see results from current investments before they made major additional public commitments in the space. Thus far, most donor investments have been in specific D4Ag projects and solutions, with the possible exceptions of the World Bank's climate-smart agriculture surveillance systems and agriculture data observatory investments and the BMGF's portfolio, which has always had a substantial share of D4Ag public good investments such as, historically, investments into the Africa Soil Information System (AfSIS) and GODAN and, more recently, Innovative Solutions for Decision Agriculture (iSDA) and national D4Ag data systems in Ethiopia.

Lately, there has been some shift in donor interests towards ecosystem building and investing in D4Ag public goods like data systems, AgTech incubation/acceleration ecosystems, cross-sector data, data analytics, and knowledge partnerships. However, the focus on public goods and enablers is still relatively new; we believe this is a critical area for future focus, as we will discuss in Chapters 5 and 6.

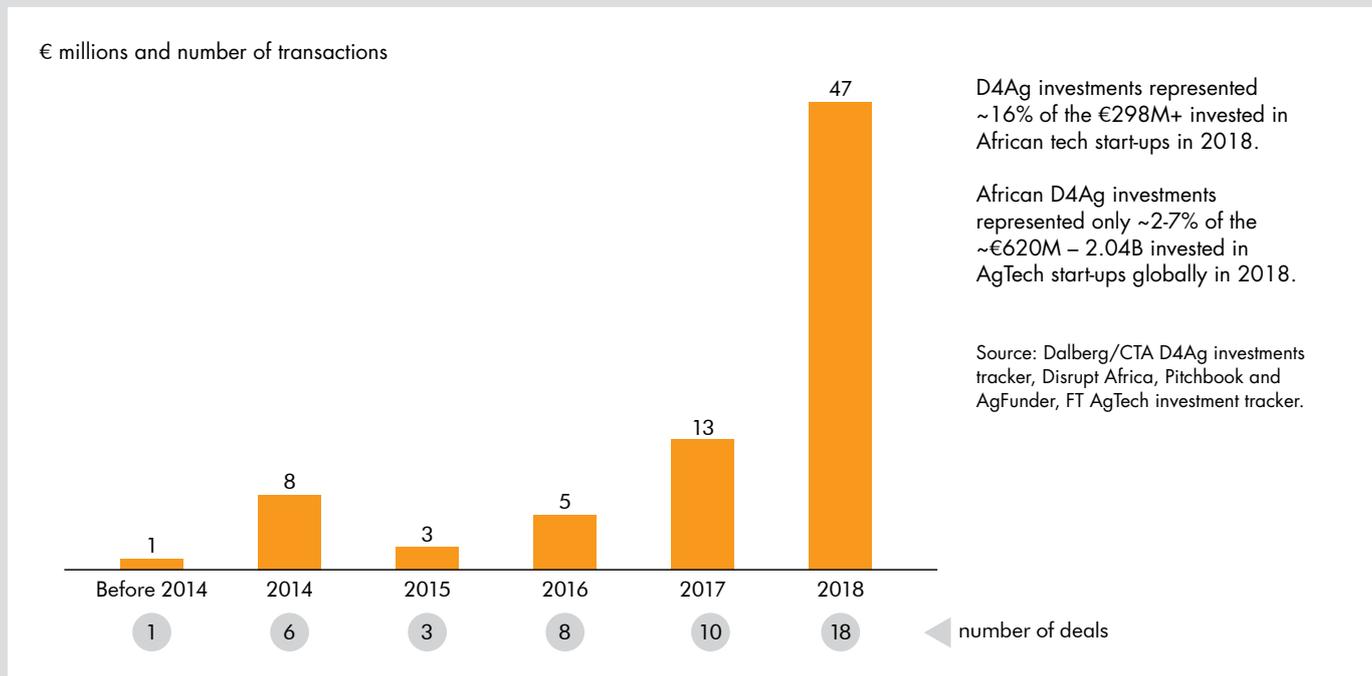
Figure 33 provides an overview of major donor activities and priorities in D4Ag based on publicly available information and interviews.

Private capital

The amount of private sector capital flowing to D4Ag enterprises remains small, but has recently increased dramatically. We estimate that about □47 million of PE/VC investment flowed into D4Ag in 2018 (Figure 32).³⁶² While this figure represents a tenfold increase over 2016 and a nearly fourfold increase from 2017, it still constitutes a small share (<16%) of the



Figure 32 Value and volume of VC/PE investments into the African D4Ag sector



€335M flowing to tech start-ups in Africa in 2018.³⁶³ Just two companies – Twiga Foods and Gro Intelligence – received nearly 2/3 of the funding to D4Ag enterprises in 2018. An additional 10+ smaller enterprises – including Ignitia, Tulaa, and Cowtribe – were able to raise significant amounts of seed or Series A funding, ranging from €270,000 to €900,000. More than 60% of the deals were equity based.

Despite this growth, private investment in D4Ag remains nascent. Total investment of €47 million is minimal relative to the need, and represents only a small fraction of private capital flowing into AgTech globally, estimated at approximately €1.8 billion in 2017 – a roughly 30% increase over 2016 – before levelling off in 2018.³⁶⁴ Mainstream investors still see most African countries – with a few exceptions – as relatively risky. Those who are investing in Africa tend to view FinTech and perhaps InsureTech as more attractive sectors than D4Ag, which shares many of the same underlying risks but is characterised by even lower levels of regulation and greater access issues in rural areas, among other challenges.

Big tech activity

The entrance of big tech firms will advance the data revolution in new ways. Big tech firms see new opportunities for themselves to play a positive role within this data-driven approach to agricultural transformation. Some players may want to better understand the space itself – given that the majority of Africa's over 1.2 billion people work in agriculture, understanding the agricultural labour force better will provide big tech actors insights into a massive potential user base, one that has historically been harder to get to know. Other players hope either to sell their products (e.g., cloud storage) or provide technology-related services – from analytics services to human capacity building – to agribusinesses and commercial enterprises. Still others may simply see value in experimenting with the extent to which technology can transform agriculture. These actors invest heavily in research and development and are capable of launching cutting-edge applications.



Figure 33 Major donor activities in D4Ag

Donor	Approach to D4Ag investment
European Commission (EC)	<p>The European Commission is a major funder of agricultural transformation in Africa and, based on our estimates, the top funder of D4Ag programmes in Africa across a variety of national and regional projects.</p> <p>The EC has a broad set of objectives for D4Ag, which cut across different EC (DG DEVCO) units involved (i.e., Sustainable Agriculture, Digital4Development), with a primary focus being to promote D4Ag programmes and solutions that strengthen food and nutrition security, and advance the climate-smart agriculture agenda, while also contributing to sustainable development and job creation in Africa's agri-food sector and rural economy.</p> <p>The EC is the principal funder of CTA, which operates within the framework of the ACP-EU Cotonou Agreement. The EC also supports a number of projects in D4Ag across the continent via country delegations, ranging from digitally-enabled advisory services to market linkages to digital financial services and innovative climate-smart agriculture programmes focused on the use of remote sensing, drones and weather surveillance systems.</p>
Bill & Melinda Gates Foundation (BMGF)	<p>BMGF's major priority is agricultural transformation, with an emphasis on smallholder farmers. The foundation has a multi-billion dollar agriculture development portfolio of which a small but substantive portion is focused on D4Ag solutions and agriculture data projects. Since 2008, BMGF has spent over ~€400 million on D4Ag grants, typically averaging 5–15 D4Ag grants annually, with a focus on both global D4Ag public goods and country-level D4Ag programming centred on India and three countries in Africa (Ethiopia, Tanzania, and Nigeria).</p> <p>BMGF has maintained an ongoing commitment to the D4Ag sector, releasing new ICT4Ag and DFS for Agriculture strategies in 2017–2018 and continuing to grow its portfolio across digital interventions with a particular focus over the past year on Ethiopia's D4Ag ecosystem, digital agriculture data public goods (e.g., iSDA and Agronomy to Scale initiatives), and a range of digital financial services and market linkage grants.</p> <p>The Foundation's D4Ag programming is driven by its Digital Farmer Services team, which believes that digitally-enabled innovations in technologies, services, and platforms can rapidly increase the ability to scale and provide farmers with diagnoses of soil health and crop nutrition, access to financial services and inclusive markets, and learning opportunities to inform farm planning and practical field operations. The Foundation's priorities include playing a strong catalytic role in advancing cost-effective D4Ag business models and supporting national/state-level D4Ag platforms.</p>
Dutch Ministry of Foreign Affairs (Dutch MFA)	<p>The Dutch Ministry of Foreign Affairs prioritises D4Ag activities highly through its funding of the Geodata for Agriculture and Water Program (G4AW) and other country-level activities that sit at the intersection of food security, water, climate sustainability, and digital for development.</p> <p>G4AW's mission is to "improve food security in developing countries by using satellite data." To this end, G4AW "promotes and supports private investments for large scale, demand-driven and satellite-based information services" and "provides a platform for partnerships of public organisations, research institutions, private sector operators, NGOs, farmer cooperatives, satellite data/service operators, business and transmission operators." G4AW works via a number of partners in Africa and Asia. For example, G4AW has partnered with Alterra in Ethiopia on CommonSense, CTA in Uganda on MUIIS, SNV in Mali on STAMP, and Rainforest Alliance in Ghana on SAT4Farming – and a number of other D4Ag solutions in our database.</p>
Syngenta Foundation for Sustainable Agriculture (SFSA)	<p>Syngenta Foundation's mission is "to create value for resource-poor small farmers in developing countries through innovation in sustainable agriculture and the activation of value chains." Digital is not the central goal of their investments, but rather a means to an end of helping farmers. Nevertheless, the Syngenta Foundation has invested in a number of digital solutions – using its standard "pipeline approach: proof of concept, scale-up, handover."</p> <p>The Foundation's new D4Ag strategy is premised on the beliefs that (i) digital is an enabler, and not a solution in itself; (ii) agriculture field forces must be equipped to drive agriculture sector change; and (iii) commercial viability is key to driving innovation.</p> <p>The Foundation believes that the time is right to accelerate the use of digital tools in sustainable agriculture and that such solutions can dramatically reduce the costs of engaging and supporting smallholders, as well as better integrate a complex web of value chain stakeholders. To this end, SFSA is currently focused on supporting the better understanding and analysis of D4Ag business models, promoting the development of holistic and commercially viable D4Ag solutions that arm field forces with the tools they need to deliver value to farmers, strengthening the agricultural financial market through digital tools and approaches, and ensuring wide collaboration and good governance across the D4Ag ecosystem.</p>



Figure 33 Major donor activities in D4Ag (continued)

Donor	Approach to D4Ag investment
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	<p>With expertise in both sustainable agriculture and digital technology, GIZ has invested heavily in recent years in developing the digital side of its work on agriculture. Through its central team and country-level programmes, GIZ has worked on most D4Ag use case areas covered in this report, with a particular focus on digitally-enabled information and advisory services, including market and climate-smart agriculture information services, digital input and off-take market linkages, and digital supply chain and logistics management tools.</p> <p>In 2018, GIZ launched both a blockchain lab and data lab, contributing to efforts around data for development and, in particular, the SDGs. Additionally, GIZ is a signatory to the Principles for Digital Development and aims to add value to the D4Ag space via sector coordination.</p> <p>While a good deal of GIZ's work in the D4Ag space is focused on public good creation, new D4Ag tool development for specific projects, and innovative business model pilots, GIZ is also focusing on broader private sector partnerships to develop and promote economically sustainable approaches to D4Ag solution scale-up. As an example of such work, GIZ has partnered closely with SAP on several D4Ag projects that ultimately contributed to the development and roll-out of SAP's Rural Sourcing Management platform.</p>
World Bank	<p>The World Bank Group is a leading global financier of agriculture, with \$6.8billion in new commitments to this topic globally in 2018, typically through large multi-year national or regional agriculture transformation programmes. Very little of the Bank's annual funding is explicitly earmarked for D4Ag overall or D4Ag in Africa, but digital and technology components are embedded in many programmes (80%+ of WB agriculture projects).</p> <p>In 2017, the Bank formed an internal community of practice with a focus on digital agriculture, particularly digitally-enabled extension services. The Bank also produced a major ICT4Ag report in that year. In 2018, the Bank began to develop a disruptive technology for agriculture strategy and formed an expanded central team to address this topic.</p> <p>The Bank's Africa AgTech strategy (which goes beyond D4Ag to include other topics like off-grid energy for agriculture) is being finalised in mid-2019, building on the launch of a Disruptive Agricultural Technology Challenge and Conference in Nairobi in April 2019. The Bank's new strategy will focus on supporting the development of AgTech incubation ecosystems across the continent, supporting AgTech entrepreneurs, and, critically, linking AgTech innovations to large Bank agriculture transformation programmes at the country level to ensure farmer impact, starting with Kenya in 2019. Key areas of D4Ag focus include digital solutions for agricultural productivity (advisory services, mechanisation, input linkages), market access, financial services, and data collection and agricultural intelligence.</p>
USAID	<p>USAID has been a long-time thought leader on the topic of ICT in agriculture. Until 2018, USAID's work on this topic was coordinated by a Digital Development for Agriculture Team within Feed the Future, which focused on advancing the knowledge agenda on topics such as the use of data for agriculture, digital financial services for smallholder farmers, AgTech innovations (remote sensing, drones, field sensors), case studies of digitalisation business models, and overall tracking of D4Ag impacts. In support of this mission, in 2016, USAID launched an annual DC-based ICT4Ag summit that remains one of the central global events for this sector, with a global agenda but a strong Africa focus.</p> <p>Country-level D4Ag programming at USAID is highly decentralised at the mission level, with limited central visibility into D4Ag spending, project-level tools, data, and partnerships.</p> <p>In 2019, USAID is developing and launching a new ICT4Ag strategy under the leadership of a small central team that will focus on the following priorities: (i) understanding D4Ag trends and impacts (i.e., knowledge management and market intelligence); (ii) supporting effective use of D4Ag tools in the field (i.e., central D4Ag expertise function for USAID missions); (iii) working on innovative D4Ag data analytics projects with the USAID analytics division; and (iv) working with development partners to foster open, inclusive, and secure D4Ag data ecosystems.</p>



Big tech players currently seem to focus on 1) gathering various kinds of agricultural data; 2) experimenting with new uses of advanced technologies; and 3) partnering with other (often local) organisations to do so. Big tech actors have deployed tools to assist with data collection – for example, IBM is assisting Hello Tractor’s efforts to compile a transaction database while SAP is helping develop farmer databases. Big tech players are also launching programmes that creatively use advanced technologies – in supporting Hello Tractor, for example, IBM is using blockchain, IoT, and IBM Cloud. A number of other actors remain in test and pilot stages of solutions that use advanced technologies, with launches anticipated soon.

Importantly, nearly all big tech activity in Sub-Saharan Africa’s D4Ag space involves partnerships with other actors, whether local enterprises, agribusinesses, or NGOs. We are optimistic about this partnership model as it allows for a combination of expertise. Overall, big tech players are making significant inroads and could scale up pilot programmes quite quickly.

The impact of these large players on D4Ag will be significant. Given their in-house capabilities, reach, and wallets, big tech players are capable of accelerating this data-driven phase. Additionally, we expect that their activity and investment will likely spur additional investments in other layers of the ecosystem, such as connectivity and tech infrastructure. In some cases, big tech companies may be inclined to build out the necessary infrastructure themselves (to some extent, this has already begun to happen – much more is planned). This has the potential to create a virtuous cycle of improved tech infrastructure with greater reach, which will drive a greater number of users and more data to better serve those customers.

But it is important to note big tech’s limits. These companies need to partner with local players in order to respond to on-the-ground realities. Big tech can equip enterprises to better serve farmers and accelerate agricultural transformation, but this support does not replace the need for very strong local talent. The capabilities of big tech companies should instead be complementary to organisations on the ground. Local players

Clarissa Baldin, IFAD



are best positioned to understand farmer needs, design products that will serve them well, and build business models that work in local contexts. By the same token, they may lack the bandwidth or resources to complete the more expensive, technical back-end work. Meanwhile, big tech players are well positioned in terms of resources to do much of the powerful processing. Therefore, partnership will largely define success as advanced technologies take off in D4Ag. The best models will be those that pair localised knowledge with big tech capabilities. Additionally, big tech players have an opportunity to support human capacity building themselves (e.g., training local teams on how to build and use artificial intelligence technology).

Of course, the entry and scale of big tech actors come with their own risks, including data breaches, misuse of data, and adverse effects on smaller and local D4Ag enterprises. As such, their entry needs to be accompanied by thoughtful regulation. An additional risk is that proprietary technologies could create walled gardens. We discuss risks further in Chapter 5.

The deep dive box in Figure 34 on the next page elaborates on specific D4Ag activities of a number of big tech players.

An enhanced enabling environment will fuel substantial D4Ag expansion

Continued improvements in phone ownership will drive increased access to D4Ag solutions.

There are several ways to understand smallholder farmer access to mobile phones, and thereby access to D4Ag solutions. GSMA estimated unique mobile subscription penetration in Africa is 45% as of the end of 2018.³⁷³ Though difficult to quantify precisely, given that they predominately live in rural areas, the number of unique subscriptions for smallholder farmers is likely in the 38–40%

range (based on historic ratios between urban and rural unique subscriptions in Africa).³⁷⁴

Unique subscriptions, however, likely underestimate the smallholder access to phones. Country-level data from a handful of countries in Africa suggest that individual smallholder farmer phone ownership is closer to 60% or more.³⁷⁵ Phone ownership at the household level is likely even higher – closer to 70% or more. There are still other ways to measure access to mobile phones (e.g., percentage of farmers who have ever used a mobile phone, or percentage of farmers who are able to access mobile phones outside of their home, rural 2G penetration).

Irrespective of the methodology, the critical point is that a large percentage of smallholder farmers already have access to mobile phones today, *within their own homes*. This figure is expected to continue to grow, e.g., GSMA expects that unique subscriptions will grow to 51% by 2025, likely 55%+ by 2030, and we estimate that this will translate to nearly 80–85% phone ownership at the smallholder farmer household level, with the vast majority of these phones being smartphones by that stage.³⁷⁶ In addition, two-thirds of the total connection base will be digitally connected through smartphones by 2025, compared to just ~36% today. This means that not only will more farmers have access to simple feature phones, but also an increasing number will be able to engage with D4Ag solutions that rely on smartphones.

Unreliable internet connectivity and high data prices will likely remain barriers in the immediate term but private actors are racing to overcome them. For now, the challenges around connectivity and high data prices confirm the continued relevance of SMS/USSD solutions in the near to medium term. Interviews have indicated that D4Ag enterprises are, in parallel, actively working to develop applications that get around connectivity-related constraints for smallholder farmers (e.g., solutions powered by near-field communication). In the medium term, we



expect to see MNOs continue to invest in expanding 3G and 4G coverage. Some major telecoms in Africa have already begun to explore and in some cases begin the transition to 5G, though this growth is expected to be uneven and is still in its earliest stages. Finally, there are several companies that are racing to invest in expanding connectivity across the continent, using, among other innovative technologies, satellites (e.g., Space-X's Starlink initiative), balloons (Google's Project Loon), internet exchange points (Facebook, in

conjunction with the Internet Society), and high-speed fibre optics (Google's Project Link). Overall, connectivity will become less of a barrier as the D4Ag market matures over the next decade. The sector will likely face a more practical issue of turning registration into actual use – a challenge that we will discuss in Chapter 5.

Continued growth in digital payments access will increase and pave the way for D4Ag enterprises to engage with

Figure 34 **Big tech making big waves in D4Ag**

IBM

IBM has partnered with a few of the most successful D4Ag enterprises across the continent, including a partnership with Twiga Foods to establish a credit system leveraging blockchain technology. The programme is set to pilot among 220 retailers in Kenya, but if successful, IBM and Twiga Foods plan to roll out the platform to agriculture SMEs across Africa. During the first weeks of the pilot, the initiative extended loans averaging KES ~3,000 (€26.5) per beneficiary, which increased the profits of each retailer by 6% on average.

IBM is also working with Hello Tractor in Nigeria to apply IBM's Watson Decision Platform for Agriculture, blockchain, the IoT, and the IBM Cloud to Hello Tractor's mobile app. The objective is to capture an immutable record of all transactions from the first tractor request until the farmer has ploughed the field and returned the tractor. A database of transactions could improve the efficiency and impact of Hello Tractor's services.

Going forward, IBM even plans to leverage image recognition to determine the quality of the cultivation and to expand the service across Kenya, Mozambique, Senegal, and Tanzania. Most recently, IBM has entered into a major partnership with Yara to "build the world's leading digital farming platform, providing holistic digital services and instant agronomic advice."³⁶⁵ By the end of 2019, they plan to begin by offering hyperlocal real-time weather forecasts along with actionable advice and recommendations based on weather data. While the partnership is global in nature, and initially plans to target Asia, Brazil and Europe, Yara has said that it plans to reach African farmers "very soon."

Microsoft

Microsoft has entered the African market with a focus on precision agriculture and AI technology. In collaboration with Techno Brain, Microsoft is working on a new Agriculture Data Platform in East Africa. Via Microsoft's intelligent cloud system, the partners are seeking to collate data on rainfall, land type, and soil nutrition and create customised and wide-ranging farm management advice on crops, harvest timing, and pest control. The project is expected to pilot in Malawi and Tanzania in 2019. In addition, Microsoft's FarmBeats technology, which uses IoT and AI to streamline farm operations, has moved one step closer to a public release of its innovations.

SAP

SAP is currently focusing on applying its software technology to develop comprehensive farmer databases and to connect smallholder farmers to larger agricultural value chains. SAP has created a software system called Rural Sourcing Management, which is designed to collect and share data on farm characteristics and input/output transactions.

In Nigeria, SAP is working with CBI Nigeria to integrate 850,000 small maize farmers into the agricultural value chains. In Côte d'Ivoire and Ghana, SAP's software has helped one of the world's leading chocolate manufacturers, Barry Callebaut, to develop a supply chain management tool to onboard ~200,000 farmers since 2016. And in Uganda, the company's cloud-based solutions have supported the efforts of Kalangala Palm Oil Grower's Trust (KPOGT) to improve the income of its 2,000 farmers. SAP's software enables KPOGT to both communicate market prices for palm oil to its farmers and to inform local oil palm companies of when deliveries are expected.



smallholder farmers in a more cost-effective way. According to recent GSMA data, 135 mobile money services supported more than 120 million active accounts in Africa in 2017, representing a growth of 18% compared to 2016. Much of this growth came in rural areas and will continue to do so in the years to come. While Kenya has long been an African leader – and world leader – in mobile money, with solutions such as M-Pesa and Equitel, over the past few years, MTN Mobile money has expanded to more than

15 countries, Paga has begun tapping into the Nigerian market, and the Bank of Kigali has added more than 1.5 million users to its mobile money platform in Rwanda. Looking ahead, these national initiatives will be accompanied by a new joint venture between MTN and Orange (with support from the BMGF), called ‘Mowali,’ which has the potential to reach beyond the African powerhouses and extended digital financial services to millions of rural households across the continent.

Google

Google has partnered with ISRIC World Soil Information to make soil maps widely accessible. The BMGF-funded Africa Soil Information Services (AFSIS) project has released maps that predict “more than 20 soil properties at six standard depths at 250 meter resolutions.” AFSIS created them with “new analysis, statistics, field trials and crowdsourcing.” The public can explore these maps for free via Google Earth.³⁶⁶ Furthermore, Google Maps and FAO are collaborating on climate change resilience and mitigation. Google has brought big data, cloud computing, and mapping capabilities to the table and partnered with FAO “to make remote sensing data more efficient and accessible.” Satellites can track a host of climate change-related metrics (e.g., deforestation, land usage).³⁶⁷ Through its foundation, Google is currently exploring its options for engaging on African smallholder agriculture, but has no formal programming announced at this stage.

Bosch

Bosch’s technologies are currently helping support the creation of value-additive activities in different markets. Bosch’s packaging technology has enabled the growth of the processing sector for coffee in Ethiopia and cassava in Nigeria, value that was previously being left on the table.³⁶⁸ Looking forward, Bosch is evaluating the possibilities of big data and artificial intelligence in transforming agriculture. Bosch has begun to develop digital applications that will allow algorithms to assess plants, insects, and weeds (i.e., via photographs) and inform farmers on better input usage, agricultural practices, and likely much more.³⁶⁹

TCS

TCS has two agricultural analytics platforms that have expanded or piloted in Southern Africa. These platforms compile various

kinds of information (e.g., on soil moisture, weather, prevalent diseases) that can help farmers.³⁷⁰ TCS’s best-known solution is mKRISHI in India, which receives questions from farmers via IVR, and replies via SMS and IVR. This network is used as an advisory information dissemination channel as well. Given mKRISHI’s success in India and TCS’s expansion into Africa, it would be a natural step to launch a solution similar to mKRISHI in Southern Africa, perhaps fuelled in part by the aforementioned analytics platforms.³⁷¹

Alibaba

Alibaba has already played an important role in transforming Chinese agriculture through its Rural Taobao business (profiled in depth in Chapter 2) and other innovations such as ET Agricultural Brain, which uses artificial intelligence and machine learning (using a combination of visual recognition, voice recognition, and real-time environment monitoring) to help farmers care for their livestock and crops.

Alibaba has already made Africa a clear priority for its growth. It has invested in several projects to help improve the ecosystem for e-commerce, including the Netpreneurs network (which is building entrepreneurial capabilities on the continent), the new economy initiative (targeting policy markets) and a partnership between the Alibaba Business School and University in Rwanda to develop commerce-oriented curriculum, among others. In late 2018, Rwanda joined Alibaba’s Electronic World Trade Platform (eWTP), which “provides small and medium-sized enterprises with operational infrastructure, such as commerce logistics, cloud computing, mobile payments and skills training.” These initiatives highlight a clear vision for how Alibaba plans to build the enabling environment and the level of importance it is placing on national-level partnerships. Given the company’s broader aspirations in Africa, and its success with cutting edge D4Ag solutions in China, it is quite possible that the company will make a major foray into D4Ag in Africa in the near future.³⁷²



The expected increase in mobile money potentially will serve as an entry point for new digital solutions and is important to facilitating D4Ag transactions. In Rwanda, Kumwe Harvest highlighted that it was able to drive down its transaction costs, as all the farmer cooperatives it worked with relied exclusively on digital transactions. Going forward, mobile money will enable more D4Ag enterprises to develop sustainable business models.

An improved start-up scene will likely result in greater talent. Since 2016, the number of tech hubs across Sub-Saharan Africa has nearly doubled from 239 in 2016 to more than 440 in 2018.³⁷⁷ Equally exciting are the players entering the scene: Google recently announced the first 12 start-ups participating in its Launchpad Accelerator in Africa, Facebook has entered the Nigerian start-up scene by partnering with CcHub to establish the new tech-focused NG Hub in Lagos and MTN ramped up its involvement in developing local tech products and services with its Y'ello Startup hub in Côte d'Ivoire.

More recent incubation efforts have focused specifically on agriculture and agribusiness. For example, SmartHectar and enpact launched an innovation hub for agriculture technology, food technology and water technology in West Africa (based out of Ghana) in 2019. The World Bank is in the process of setting up a new AgTech incubator and accelerator in Kenya as part of the broader WB Disruptive Technology for Africa strategy and is considering replicating this approach in other African countries, such as Nigeria. A larger and more diversified tech start-up ecosystem will likely bring improved technology and catalyse greater investments in local start-ups, including in agriculture. Equally important, a richer ecosystem could bring in new talent and develop local talent.

Adding it all up...

Extrapolation from historical trends suggests that the the D4Ag sector could grow to nearly 100 million registered farmers by 2022. Our D4Ag survey respondents self-reported that the number of farmers registered for their D4Ag solutions

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grew 44% annually over the three-year period ending in 2018. Several of the biggest D4Ag enterprises in Africa did not respond to the survey, but follow-up interviews with large players such as Digital Green, PAD, WaterWatch Cooperative, and Digifarm indicated that this sort of growth rate is broadly in line with the overall African D4Ag sector and, if anything, is slower than the registered farmer growth rate of some of the market leaders. When asked for their three-year projections for the path forward, survey participants reported, on average, that they expected an annual growth rate of 55% in registrations through 2022. Large D4Ag sector actors not included in the survey data each reported plans to digitise low millions and in one case tens of millions of smallholders over the next five years.

Using the more conservative historical growth rate of 44% leads to ~100 million registered farmers by 2022, or triple the farmers registered for D4Ag solutions today.

The number of unique users actually engaged with D4Ag solutions is far more modest in this projection. Before delving

into the realism of these figures, it is important to note that these numbers refer to the overall number of farmer registrations for D4Ag solutions, rather than the unique number of farmers registered for D4Ag, and certainly not the number of farmers engaged with or actively using such solutions on a regular basis.

For the baseline, our analysis concluded that there were ~33 million registered farmers today (see Chapter 3). Based on interviews and smallholder survey data from countries like Kenya, we estimated 20% duplication (i.e., users registered to multiple D4Ag solutions), which would mean ~26 million unique users today. Our database indicates that roughly 42% of those registered for D4Ag (or approximately 11 million farmers) are ‘engaged’ to the extent that they have used the solution to even a moderate extent after registration. Other users have registered but do not use the solution.

Applying the 44% historical growth rate for registered farmers to unique users yields a projected ~80 million total unique users and 33 million engaged unique users by 2022 (see Figure 35).

Georgina Smith, CIAT



Even with such adjustments, the number still appears aggressive. It implies that ~54 million farmers – 18 million per year – will be registered over the next three years, up from 11 million unique farmers registered in 2018, leading to a total penetration rate of roughly a third of all smallholder farmers in Africa by 2022. In some ways, these numbers are not unprecedented – for example, Cellulant took just a few years to register 17 million Nigerian farmers for its e-wallet as part of the Nigeria SES subsidy scheme. In the absence of such national schemes, however, this pace of farmer acquisition appears hard to sustain.

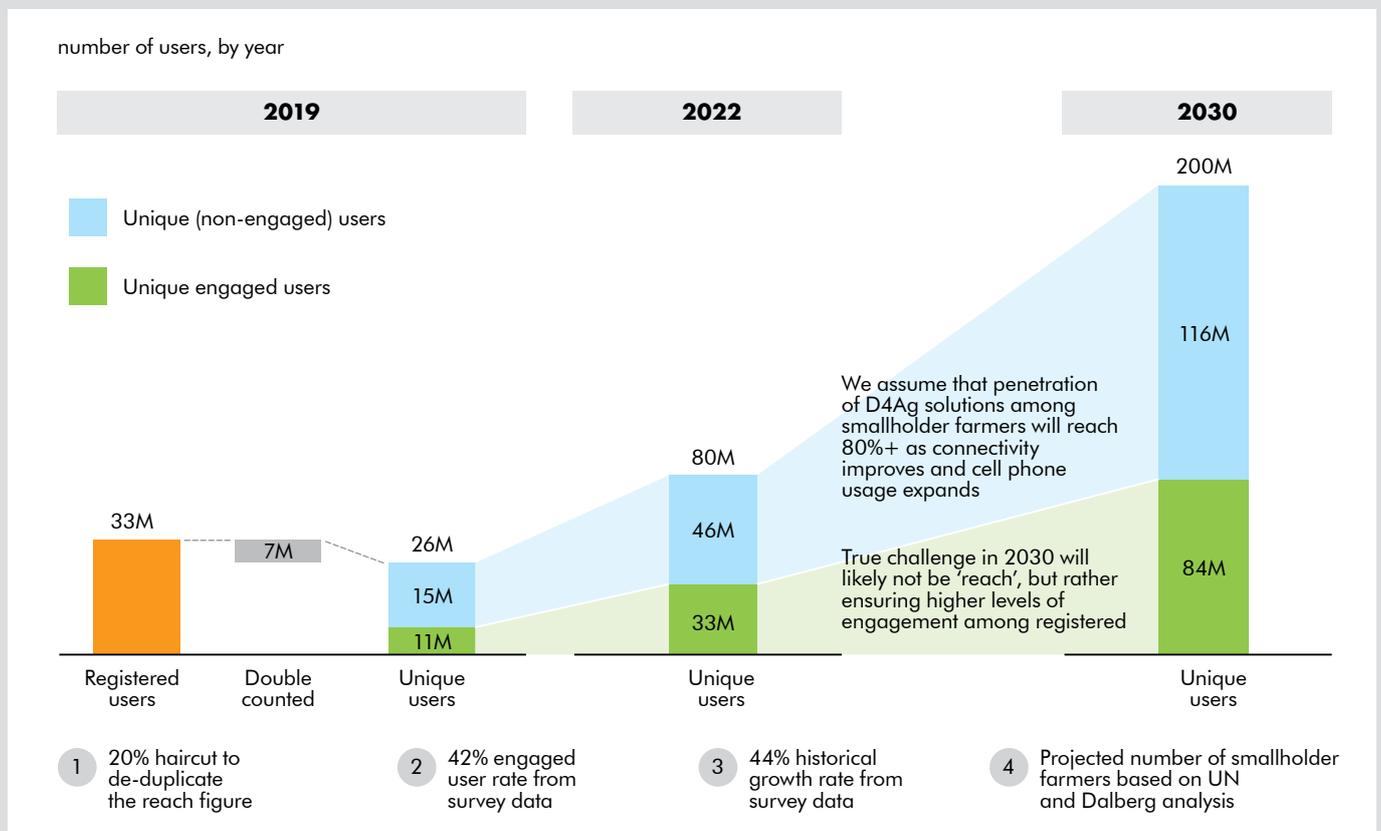
Even if one believed that the growth rate for D4Ag registrations was likely to slow down dramatically after 2019, an annual growth rate just half of what was seen in the past few years (22%) would still lead the number

of unique registered farmers to grow from 26 million to 47 million in 2022. This would mean adding ~20 million farmers over the next three years, roughly the same absolute number of new farmer registrations as the pace of farmer registration over the past three years (2016–2018).

We propose this 47 million farmer figure as the very conservative scenario for potential unique farmer reach and 80 million unique farmers registered in 2022 as a highly optimistic figure.

What these figures reveal more broadly, however, is that farmer registration is not the binding constraint for the sector. Looking forward to 2030, we believe every farmer with a cell phone will use at least one D4Ag solution. If we assume the number of

Figure 35 **Projected unique registrants and engaged users, 2019–2030**



smallholder farmers in 2030 to be 250 million (i.e., the same as today) and the connectivity rate to be 80% (per the discussion in Chapter 3), we would expect around 200 million unique users. Based on current engagement levels, we expect only ~84 million engaged users in 2030. The number of truly active users is likely much lower – perhaps half of all engaged users based on our desk research and interviews. The greatest challenge over the next decade will not be reach but rather increasing levels of engagement among registered users.

These trends suggest that the next 3–5 years are likely to be transformative for D4Ag and will build the foundation for even more dramatic changes through 2030. D4Ag success stories are just beginning to emerge, and we believe the sector could go much farther – especially in use, inclusivity,

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These trends suggest that the next 3–5 years are likely to be transformative for D4Ag. ”

and impact. This growth will likely not occur evenly across all segments of Sub-Saharan Africa’s smallholder population, however. Smallholders, particularly men, in countries with stronger enabling environments will likely enjoy significantly improved access to D4Ag solutions, while access for others may expand at a slower rate or – in certain environments – not at all. The ability of the D4Ag sector to surmount such accessibility barriers, particularly among more marginalised populations, will depend on the concerted efforts of all sector actors to overcome the D4Ag challenges outlined in the next chapter.

Tamiru Legesse, FAO



WHAT IT WILL TAKE TO ACCELERATE GROWTH AND IMPACT



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In our efforts to build a strong, foundational D4Ag ecosystem that will support sustained, inclusive growth, too much focus has been placed on experimentation and short-term success.

Progress toward a strong D4Ag ecosystem is promising, but the sector still faces a number of challenges.

Some of the challenges are specific to the D4Ag ecosystem while others – e.g., national agronomy R&D systems, agricultural policies, and rural land tenure – apply to agricultural transformation more broadly. We discuss these challenges in this chapter.

We do not address connectivity because the broader market is already making significant progress toward overcoming this issue. Additionally, we do not address non-digital

infrastructure because D4Ag will not eliminate the need for it. Digital tools can improve market efficiency, transparency, aggregation, and integration, but parallel investments in physical infrastructure (e.g., roads and electricity) are still needed to deliver inputs to farmers, to deliver farm products to markets, and to power production and post-harvest agricultural equipment. Governments, donors, and others must invest directly in necessary non-digital infrastructure in order for agricultural transformation to occur. Similarly, the significant investment and ongoing costs required for human infrastructure (e.g.,

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Successful D4Ag solutions are evolving faster than the ability of the enabling environment to support them. ”



extension agents, financial agents, and agro-input dealer networks) are crucial to achieving real agricultural transformation and impact.

Four main challenges significantly limit the role D4Ag is currently able to play in advancing inclusive agricultural transformation in Africa: (1) there is insufficient tech-savvy human capital to support D4Ag solution development and support, matched by the problem of low end-user digital literacy, (2) the sector underinvests into D4Ag infrastructure, particularly enabling agriculture data systems at the national level, (3) poorly calibrated government policies hinder or fail to encourage D4Ag ecosystem development, (4) companies still struggle to develop viable business models and (5) D4Ag is growing unevenly across the continent. If we overcome these challenges, the sector could very likely grow faster and become more inclusive in the coming decade.

Successful D4Ag solutions are evolving faster than the ability of the enabling environment – skills, policy, and middleware – to fully support and take advantage of them. While some enabling factors such as connectivity and mobile money have improved, others lag behind, even as recognition of their importance grows among donors and policymakers. In order to meet the demands of D4Ag, the enabling environment must improve human capital, develop and enact supportive agricultural technology policies, and fund and build out D4Ag infrastructure, particularly agricultural data systems, that will enable D4Ag solution scale-up and impact.

Insufficient human capital development among D4Ag creators and consumers limits the range of solutions offered and the uptake of the ones that do exist

The low concentration of refined ICT skills in most African countries can

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49% of D4Ag enterprises surveyed for this report reported human capital as a key growth challenge.”

constrain the growth of D4Ag solutions on the supply side. Despite the efforts of African-focused tech staffers like Andela and technology hub communities like Nairobi and Lagos, local skill development for software and product creators, data analysts, product implementers, and monitoring support remains largely insufficient. Even in countries with more advanced technology ecosystems like Kenya and Tanzania, one out of three firms described ‘inadequately skilled workforces’ as a key business constraint.³⁷⁸ In Kenya, where nearly one out of five formal sector positions is ICT intensive, the agricultural sector may struggle to attract and retain workers with strong technical skills. Forty-nine percent of surveyed D4Ag enterprises reported human capital as a key growth challenge. The failure of private, public, and non-profit actors to cultivate a large volume of workers with ICT skills can compound development challenges for D4Ag enterprises, particularly in markets that struggle to attract funding due to their small size or instability.

In the absence of established start-up supports like prize competitions, university incubators, and formal networks, local tech entrepreneurship in much of Sub-Saharan Africa remains weak. For example, Senegal has not invested in the development of local digital skills, and as a result, few D4Ag enterprises exist in the country. Moreover, because they lack access to continued funding and human capital, the start-ups that do exist there struggle to advance, much less to succeed. Senegal is a relatively unattractive market for external private investors (see the Senegal case study in the Annex for more details) and without investment in local skills the whole country’s D4Ag space remains underdeveloped. Broadly speaking, in the absence of human capital,



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local enterprises struggle to scale and, in their place, foreign enterprises, likely with a weaker understanding of context, control what D4Ag space exists.

D4Ag enterprises report that low levels of digital literacy and comfort among farmers and agricultural agents constrain demand, adoption, and use of offerings. Architects of Ethiopia's wide-reaching 80-28 programme reported that, initially, users often did not understand how to dial the hotline number or cycle through call menus. Businesses around the continent cite farmers' lack of trust in phone-based transactions as a key barrier to the adoption of their market linkage solutions. **Overall, 28% of surveyed enterprises cite consumer-level barriers as a top-three challenge to D4Ag adoption and use.**

Enterprises with the time and resources to do so have either invested heavily in digital education or sought to design around literacy barriers. For example, Digital Green relies on a vast network of extension workers to facilitate video displays for farmers, while 80-28 allots time for staff to respond to non-topical calls. Over time, these investments in digital education help some farmers – particularly model farmers

and intermediaries – to familiarise themselves with useful technologies and share the benefits with others. To reduce the need for such investments, 80-28 has begun to investigate how artificial intelligence and machine learning approaches might inform IVR solutions that overcome digital literacy challenges. However, these approaches may not sufficiently tackle the digital literacy gap for another 5-10 years.

Enterprises without the time and resources necessary to confront digital illiteracy may find it difficult to grow, but actors can support digital education across multiple solutions. CTA worked with enterprises to develop a curriculum for user training, which was piloted by Farmerline in Ghana, Ensibuuko in Uganda, and FarmDrive in Kenya.

Gaps in D4Ag infrastructure, particularly in terms of under-investment into agriculture data systems

Agriculture data 'middleware' infrastructure – e.g., farmer registries, digital agronomy data, soil mapping, pest and disease surveillance, and weather data infrastructure – enabling



layer for D4Ag solutions. The lack of agriculture data infrastructure in most contexts can significantly hamper D4Ag solutions, while the presence of high-quality agriculture data ecosystems can increase their efficiency and effectiveness.

Agriculture data infrastructure in the form of national farmer registries, for example, can play a highly useful role.

Registries can support farmer identification and verification, reduce the cost and effort of data collection, help simplify agribusiness and government processes and inform policy making. Comprehensive and regularly update national-scale digital farmer databases—such as Ethiopia’s input subsidy e-voucher and 80-28 databases (4 million farmers), Rwanda’s Smart Nkunganire System (1.5 million farmers), Zambia’s ZIAMIS (1.15 million), and Nigeria’s partnership with Cellulant (17 million farmers at its peak, of which 7 million were receiving subsidy payments) – can provide governments and D4Ag enterprises with the necessary data to tailor extension services to farmers’ needs, increase access to customised farm inputs and strengthen value chains through increased traceability and transparency. These types of government-affiliated initiatives or social enterprise farmer digitalisation plays like CTA’s MUIIS solution in Uganda (250,000 farmers), can also facilitate smallholders’ access to financial services, including insurance, savings, and – most important – credit products, by allowing smallholder farmers to formally register their farms. In addition, farmer registries of this type can provide a better understanding of D4Ag’s impact on women, youth, and other marginalised groups by tracking resource flows and outcomes at the individual level.

Beyond national digital farmer registries, working closely with donors, a number of countries have launched efforts to build other types of agriculture data systems. Ethiopia, for instance, via its Agriculture Transformation Agency (ATA), is working with the Gates Foundation in 2019 on an ambitious plan to build out national pest

and disease surveillance, livestock surveillance, and advisory data systems.

Kenya recently partnered with the World Bank to build a national agroclimatic data surveillance system, the Kenya Agricultural Observatory Platform (KOAP). The Ugandan government with donor partners is working with Dalberg Data Insights, Dalberg’s data science team, to build out and scale the CubicA platform, a set of big data tools and data repositories (e.g., national scale crop maps and yield forecast maps) for monitoring key agriculture and food security trends in the country. Rwanda has a national agriculture data roadmap that goes well beyond the SNS farmer registry and is seeking to build other important agriculture data systems. Namibia and eSwatini have invested heavily into national livestock traceability systems.

Government-led digital agriculture data initiatives are, however, very few in number today.

The vast majority of African countries lack the resources and the technical capacity to build comprehensive digital farmer registries, let alone more complex agriculture surveillance systems that feature remote sensing data layers, weather data, or soil data. Beyond resource constraints, some governments discourage agriculture data infrastructure development in response to legitimate data policy concerns (noted later in this chapter) or due to less valid considerations since increased transparency and availability of information may not always be welcome.

Georgina Smith, CIAT



As a result, D4Ag infrastructure initiatives tend to be primarily donor-led at the moment. A number of such initiatives are currently picking up momentum with a regional or sub-regional lens.

For high-quality soil data, for example, the Gates Foundation has already invested extensively over the past decade into building out the digital infrastructure for soil data collection, analysis, and dissemination systems under the umbrella of its AfSIS programme, which has now been transitioned into a new social enterprise, Innovative Solutions for Decision Agriculture (iSDA). The programme made extensive progress in generating national-level digital soil maps in partnership with African countries such as Ethiopia, Tanzania, Nigeria, and Ghana, where these maps are increasingly being utilised by D4Ag actors to build value-added tools and applications. Through a recently launched partnership with the Islamic Development Bank, BMGF is seeking to scale this national soil data infrastructure to another 8+ countries in the Sub-Saharan Africa region over the next several years.

The CGIAR system, via efforts coordinated by the CGIAR Big Data4Ag initiative, is in the midst of scaling up digital agronomy platforms, which include agronomic data repositories and systems that track field trial data. The Gates

Foundation is working on a Agronomy-to-Scale (ATS) data platform concept, which would build on iSDA's soil data assets but develop much broader Africa-focused geospatial agronomy data sets and tools (e.g., crop maps).

The World Bank and organisations like the UNDP have growing portfolios of investments across the continent into climate-smart agriculture data systems and related 'hydromet' weather surveillance and early warning services, of which the Kenyan KOAP data observatory, mentioned above, is one advanced instance.³⁷⁹

Such endeavors demonstrate a significant opportunity for donors to better balance funding for specific innovations with investments in public goods. Along with this good news, however, comes a general sense from all of our sector interviews that such public good D4Ag infrastructure investments are very limited at the moment relative to the scale of the challenge and, furthermore, are overly concentrated in just a handful of African countries.

Government policies that stifle innovation or expose consumers to security risks hinder inclusive D4Ag expansion

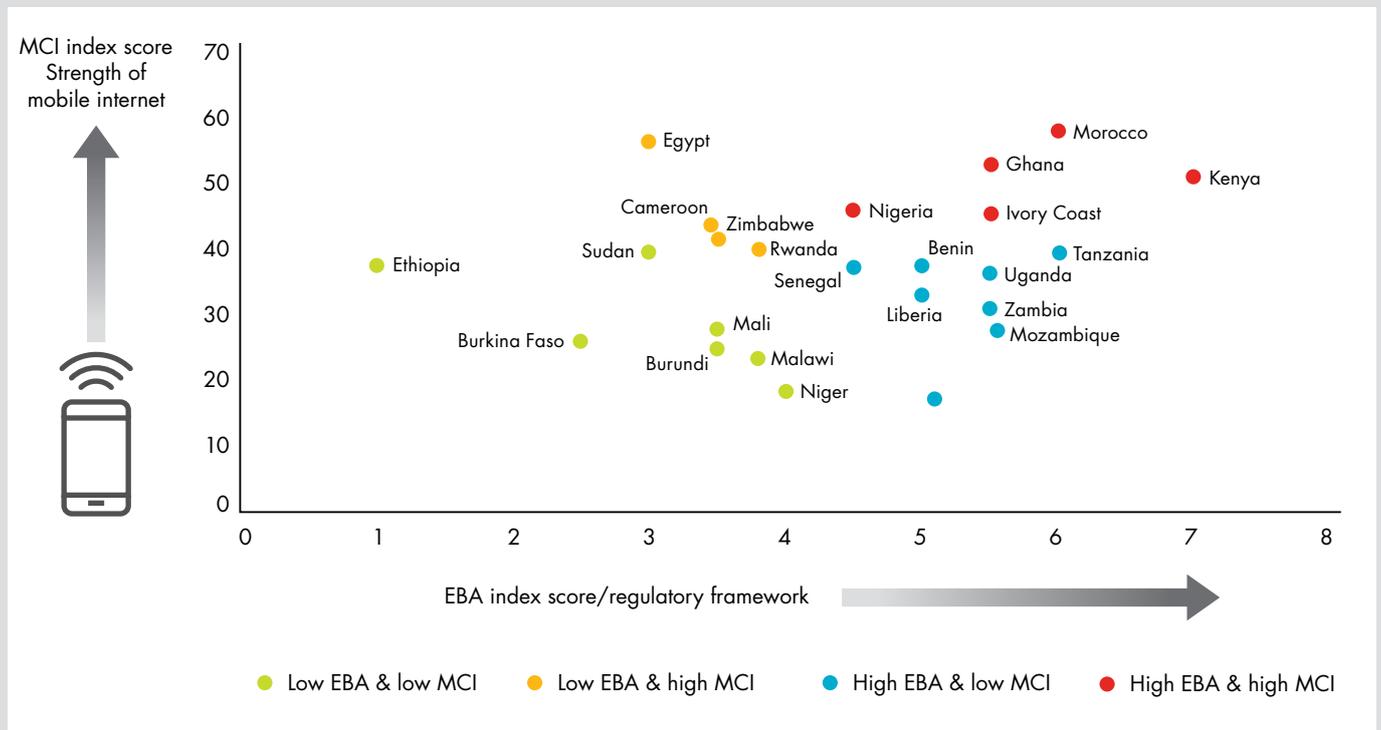
Policy frameworks that stifle innovative approaches or fail to clearly stipulate regulatory requirements discourage D4Ag innovation and investment. D4Ag solutions rely on coherent business procedures, strong financial systems, and clear regulations of digital and data processes. Inconsistency in the interpretation or implementation of policies in these areas can disincentivise innovators and entrepreneurs from entering the D4Ag space. For example, Ethiopia's conservative banking regulations forced mobile money operator M-BIRR to engage in five years of redesigns. This substantially slowed the growth of mobile money in Ethiopia. In Senegal, unexpected

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Figure 36 An illustration of country-level D4Ag readiness

Malabo Montpellier Panel's country-level ranking



changes to financial regulations forced mobile money provider Wari to shift business models after an initial period of business model success.

A lack of regulatory guidance can prove equally discouraging to investment. A Rwandan agricultural drone company hesitated to expand into neighbouring Uganda due to Uganda's lack of clear drone policies. In Senegal, e-commerce platform Sooretul struggled to formalise its business due to the absence of a policy framework. While policymakers may find it challenging to design regulations for emerging, experimental technologies, doing so can attract investment and encourage D4Ag innovation.

At the same time, the lack of policies around privacy, security, and customer protection brings unique risks to farmers, particularly in less stable

political climates. D4Ag enterprises have seized upon farmer data as a viable revenue source. This has encouraged the collection and dissemination of increasingly specific pieces of farmer information – incomes, crops, vulnerabilities to climate change, soil types, water access, etc. As a result, farmers, particularly those in politically volatile environments, are left susceptible to risks ranging from unscrupulous business practices to violence. These risks are not unique to the D4Ag space. CGAP conducted a study of 11 digital financial service providers and each of them experienced a cyber attack in 2017 that risked troves of customer data. Unlike digital finance, however, agricultural technology lacks governing data standards and principles, rules around data sharing and selling, informed consent, data security, and mechanisms for accountability and redressal, among other protections. High-profile cases in Europe and the US illustrate the dangers of leaving this



work undone. As D4Ag evolves, such systems must be prioritised more quickly, particularly given the vulnerability of smallholder farmers and the risks of losing their trust should data or security breaches occur.

Most companies are still working to develop a viable business model

While some companies have started to reach scale and turn profit, the vast majority of D4Ag enterprises still rely heavily on donor-funding. In recent years, as discussed in great detail in Chapter 4, the D4Ag sector has learned a lot about what models *do not work*, but we are still in the relatively early stages of understanding what models *do work* for most D4Ag use cases. For example, as noted in Chapter 4, experience from several businesses suggests that farmers are unlikely to pay for D4Ag services (especially advisory services) and that data is quite challenging to monetise. As such, companies are beginning to experiment with new approaches, e.g., taking a cut of the value created for customer segments, and in many cases moving to bundled service ‘super platform’ models. This may have strong promise, but companies will have to focus on

converting customer reach to actual use in order for these types of models to yield returns and to achieve scale.

Companies with business models that remain works in progress may deprioritise or miss important issues like impact, data stewardship, etc. They may believe such issues are secondary to proving their business model. For example, several companies mentioned during interviews that focusing on women was too challenging to make it an immediate priority. Donors can play an important role in ensuring the right balance between impact and business model viability, e.g., by incentivising a focus on use and impact and targeting specific marginalised segments. Similarly, donors might consider extending time horizons. Currently, most investments are made with 3–5 year time horizons in mind, but realistically, impact will take longer to achieve.

Private investment may not be reaching the countries and segments that need it the most

High degrees of country-level and regional variation in investment expose uneven growth across the continent.

While the progress in countries like Kenya serves as a strong inspiration for others, the level of variation across countries highlights some important challenges. First, it highlights that not all countries have sufficiently strong enabling environments in which D4Ag can thrive. For example, the Malabo Montpellier Panel’s recent report developed a country-level index to explore the variation in enabling environments across Africa using two primary criteria: the strength of regulatory environment and the ability to adopt and use mobile internet.^{300, 301} The report found a very uneven landscape overall, with most of the countries on the continent requiring a lot of support and enabling environment progress to truly move their D4Ag ecosystems forward.

ESADA



But variations in investment patterns and volumes also indicate that donors, investors, and – to a somewhat lesser extent – enterprises are still risk-averse and likely prioritise the easiest-to-reach markets. This also occurs within individual countries, where companies largely target the easiest-to-reach customers. This kind of uneven growth results in uneven outcomes and could further the divide between the haves and have nots.

Private investment often fails to target the poorest farmers, on whom D4Ag could have the highest impact. D4Ag solutions that attract investment tend to work through aggregators – including cooperatives, financial service providers, input providers, off-takers, MNOs, and others – that touch higher-income farmers in larger markets, despite the fact that lower-income farmers would benefit the most from these solutions. Data suggest that farmers with access to financial services, cooperative memberships, and tight value chains fare better across a variety of metrics than farmers outside these aggregator networks. Subsistence farmers, who have the lowest incomes, lack access to such services. Financial service providers are unlikely to touch smallholders and women who would likely benefit most from D4Ag.

The most financially viable opportunities utilise aggregators, particularly those in large stable markets. Since most enterprises do not charge farmers, aggregators often comprise the largest revenue stream in financially sustainable business models. For example, one enterprise that focuses on financial inclusion derives revenue from charging financial institutions per farmer who uses the product and per loan given. Aggregators can also provide a route through which to reach scale. For example, one report notes that for ACRE Africa, “strong partnerships with MNOs, input manufacturers, and local agricultural vendors ensure scalability of the product and wide reach of coverage at a low cost of service.” A digital platform in Nigeria found farmers by asking agribusinesses



which cooperatives and farmers they worked with. Through such methods, aggregators help interconnect the otherwise fragmented agricultural sector.

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Financially viable opportunities for aggregation often exist in large stable markets. Over 80% of the solutions that received the most investment were active in the top eight most populous Sub-Saharan African countries (Nigeria, Ethiopia, DRC, South Africa, Tanzania, Kenya, Sudan, Uganda). In contrast, Lesotho, Gabon, Guinea-Bissau, Mauritius, and eSwatini saw far less. There are a number of possible reasons for this discrepancy. For example, large stable markets have a larger potential use base and more expansive physical infrastructure.

Increasing investment only in large stable markets could widen the disparity between the poorest farmers and those with access to aggregators. It could further create regional divides or discourage regional integration between small and large national markets. In a worst-case scenario, these inequities could lead to community unrest, food insecurity, and violence. As the sector continues to mature, donors, investors and enterprises alike will need to work toward more equal access to D4Ag solutions across the continent.



RECOMMENDATIONS FOR FURTHERING A SUSTAINABLE, INCLUSIVE D4AG AGENDA



Agrocenta

Over the past 15+ years, the digital agriculture sector in Africa, mainly driven by donors, has launched a multitude of D4Ag enterprises and initiatives. Despite many failures and setbacks, these efforts have built a foundation of increasingly commercial D4Ag solutions – a growing number of which have promising business models and are starting to show meaningful scale. The D4Ag sector is still highly fragmented, however, the evidence base for D4Ag’s impact on smallholders is early stage for many use cases, and many other challenges to more rapid progress abound.

Efforts of digital agricultural services to become sustainable and scalable continue to face challenges. How does the sector transition from short-lived, donor-funded projects to self-sustaining, business-driven initiatives that create demonstrable impact for smallholder farmers – and how does it do so equitably?

Together, enterprises, donors, investors, agribusinesses, and governments must create an environment in which digital agricultural solutions can thrive and produce impact. In this chapter, we lay out seven priorities that will help the D4Ag sector succeed in a way that is impactful, sustainable, and inclusive. These are not wildly provocative investments



or ‘silver bullets’ for D4Ag. Rather, they are important foundational steps that will help build a sustainable D4Ag ecosystem in Africa – one that can support the mainstreaming of D4Ag efforts going forward. Political will, commitment, and engagement are fundamental to the implementation of these recommendations and need to flow across government institutions, not just agricultural ministries.

Much greater investment – on the order of several billions of euros annually rather than a couple hundred million euros – is also needed. For instance, in the US, the government spends ~€1 billion annually, on top of billions spent over the decades on underlying infrastructure, supporting the climate and weather surveillance systems that provide essential services to the agriculture community. In Africa, in comparison, investments into weather infrastructure are an order of magnitude lower in any given year for the entire continent.

In this chapter we focus on recommendations for donors, investors and governments given they are the primary audiences for this report. As with the prior chapter, we do not, herein, discuss important enablers that are not specific to D4Ag, like investments in rural connectivity, given how well understood and covered such efforts already are in other reports.

1. Develop human capital at every level of the D4Ag ecosystem

Developing human capacity will be critical to building D4Ag readiness across the ecosystem, from farmers to government ministers. The necessary growth in human capital includes increased awareness of D4Ag, improved digital literacy, and greater digital skill building among smallholder populations. Such growth will require deeper investment across Africa in

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Together, enterprises, donors, investors, agribusinesses, and governments must create an environment in which digital agricultural solutions can thrive and produce impact.”

those areas of the developer ecosystem most capable of boosting human capital, i.e., start-up ecosystems, incubators, accelerators, etc. Efforts must also be made to increase the capacity of government workers in relevant ministries to understand how to use and deploy D4Ag tools in various government initiatives.

We recommend that governments:

- Invest in ongoing training to build the digital and D4Ag skills of individuals (from legislators and ministers to IT leads and local extension agents) throughout their agricultural ministries and in other relevant ministries.
- Implement farmer digital literacy and D4Ag training programmes (with the support of the appropriate ministries, where applicable).
- Support the start-up ecosystem and encourage youth participation in incubators, accelerators, and local university initiatives.
- Participate in knowledge transfer programmes across departments and with other countries.

We recommend that donors:

- Increase support for initiatives such as incubators, hackathons, prize competitions, university classes, etc., to foster local digital skill development.
- Earmark funding for capacity building initiatives as a standard condition of grants to D4Ag enterprises.
- Help create partnerships with D4Ag enterprises and non-profits experienced in digital literacy training.
- Offer technical assistance to government capacity building initiatives.



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We recommend that investors:

- Bring in developers from other geographies to share knowledge with and build skills among investees.
- Support incubators and accelerators, especially those with a strong focus on young entrepreneurs.
- Insist that investees incorporate strong digital literacy and consumer-training programmes into their business plans.

2. Drive greater business model sustainability

While a handful of companies are starting to see positive returns, the vast majority still struggle to achieve economic and operational sustainability.

Most start-ups are unlikely to succeed. While this is consistent with other sectors and in other geographies, Africa needs to prove that D4Ag deployments can be sustainable in order to drive greater investment.

Governments, donors, and investors can help achieve greater sustainability of D4Ag businesses.

We recommend:

- Increased funding for a more diverse set of business models rather than just for those models that have already attracted funding.
- Greater focus on improved product design and consortium/platform-based approaches to drive greater value for farmers.
- A continued push toward B2B models so that enterprises can attract paying clients.
- Deeper research on D4Ag business models (see recommendation 6 for additional details).

We recommend that governments:

- Make direct investments in promising D4Ag models, where appropriate, in partnership with private investors, particularly for those agriculture value chains where governments are already active in market support or public procurement.
- Serve as paying clients for promising D4Ag solutions, especially at the proof of concept stage.
- Promote the creation of consortia that take a more holistic approach to value creation.



We recommend that donors:

- Fund high impact studies on successful – and failed – business models and share best practices.
- Require investees to share and communicate financial results (anonymously as appropriate) with the broader D4Ag community.
- Share lessons learned and best practices from investees (anonymously, as appropriate) with the broader D4Ag community.
- De-risk investments in high-impact models for investors through co-funding and increased grant/subsidy period of projects to 5–7 years for products to be ready for market.
- Promote bundling and consortium-based approaches among investees.

We recommend that investors:

- Channel greater investments into D4Ag by building upon and scaling up viable models supported by donors.
- Shift focus from companies that have already attracted significant investment to those that have attracted less investment but have promising business models.
- Allocate greater funding for product design and prototyping.



- Consider more flexible investment approaches (patient capital, innovative funding models, etc.) that are better suited to the needs of investees.
- Help build partnerships between investees, private actors, and technology providers in order to reduce technology and operational costs.
- Share lessons learned and best practices from investees (anonymously, as appropriate) with the broader D4Ag community.

3. Create greater impact by bringing D4Ag to less-served populations

Today, D4Ag solutions primarily reach the lowest-hanging fruit – farmers in tight value chains – and many enterprises fail to prioritise outreach to women and other marginalised segments. To achieve equitable growth, D4Ag needs to be more inclusive.

We recommend that sector actors:

- Offer greater support for enterprises in geographies that have historically attracted less investment but enjoying strong enabling environments.

V. Atalos, CCAFS



- Incentivise D4Ag enterprises to target marginalised segments, especially women, who are systematically left behind.

We recommend that governments:

- Attract new investors by publicly supporting D4Ag and highlighting the benefits of local enabling conditions.
- Incentivise impact-oriented investments by entering public-private partnerships with D4Ag enterprises that are committed to impact.
- Prioritise and take into account the needs of marginalised segments as part of their D4Ag investments.

We recommend that donors:

incentivise D4Ag enterprises to engage the hardest-to-reach smallholder farmers segments, especially women by:

- Incorporating gender targets as part of their investment portfolios and explicitly fund grantees who prioritise women.
- De-risking the cost of designing for specific segments – e.g., by offering grants to

enterprises for the development of product offerings tailored to the needs of women.

- Investing in gender-disaggregated data that both governments and enterprises can use to build more appropriate solutions and models.
- Directly funding and focussing attention on organisations in geographies that have traditionally received minimal funding.
- Shift expectations toward a slower return on investment than the typical three-to-five-year window. With patience comes greater opportunity for these enterprises to reach beyond the low-hanging fruit.

We recommend that investors:

- Invest in promising D4Ag businesses even if they are not located in the most obvious target markets.
- Support organisations that may be less known but that are equally as promising as those that have already received support.
- Consider incorporating specific impact metrics related to marginalised segments into their investment criteria.

Georgina Smith, CIAT



- Take on the role of a catalytic investor that can help unlock funds for D4Ag in Africa from others. (Note: not all investors need to do this, but even a few investors taking on this role could have outsized impact).

4. Invest in the missing middleware infrastructure

Successful D4Ag solutions require access to a wide range of data (from remote sensing data to farmer-specific data) in order to deliver high-quality services to farmers. This data needs to be accurate, precise, and, in many cases, available in real time. However, it is neither efficient nor effective for each D4Ag enterprise to individually collect, store, and analyse all the data it would like to access.

We therefore recommend investments in a robust D4Ag middleware layer that includes, among other items, farmer registries, digital agronomy data, soil mapping, pest and disease surveillance, and weather data infrastructure. These public goods would immediately impact side actors and could eventually benefit smallholder farmers directly. A strong, coordinated effort – rather than one-off, small-scale efforts – by multiple actors is critical to the success of such initiatives.

We recommend that governments:

- Make investments – in partnership with research agencies and donors – toward the creation of D4Ag data infrastructure and ensure that data about/for the most marginalised groups is captured as part of these efforts.
- Deploy the data infrastructure for high priority uses within their own efforts (e.g., national soil cards).
- Promote open standards and modular systems so that other government agencies and other actors can plug into and use the new D4Ag infrastructure.

We recommend that donors:

rebalance portfolios to include a greater share of investments in the D4Ag data infrastructure layer. Specifically, we recommend that they:

- Fund investments in D4Ag data infrastructure alongside governments.
- Offer technical assistance and advisory support to governments as they design and make use of D4Ag data infrastructure.
- Help identify strong implementation partners.
- Share best practices from prior efforts.

Investors, for their part, are likely to play a relatively smaller role in the creation of these public goods. Still, they can help open new markets by investing in ecosystem enablers while or even before making direct investments in enterprises.

We recommend that investors:

- Partner with technology companies to build common solutions for their investees.
- Invest in public–private partnerships (PPPs) that offer revenue-generating (perhaps with the help of subsidies) public goods, e.g., weather services, soil and crop diagnostics, etc.

5. Invest in good data stewardship and design for the risks and limitations of digital systems

The need for good data stewardship will only grow. Actors in the sector increasingly rely on algorithms. As greater investment flows into the middleware layer and as ever more significant volumes of data are captured, aggregated, and analysed, clear, conscientious standards will be necessary.



We recommend the creation and incorporation of strong D4Ag data policies and practices across Africa.

Data policies should incorporate the values of good data stewardship (e.g., protections for digital ID, user privacy, etc.) writ large and should span multiple sectors. Such values are exemplified by the emerging digital principles for development and can be augmented with recommendations that focus specifically on D4Ag (e.g., farmer registry guidelines).

Governments must lead the way on strong data stewardship efforts.

We recommend that governments:

- Work in conjunction with regional bodies to develop and enact strong privacy, security, and consumer protection laws tailored to the local context and in line with regional needs.
- Incorporate best practices and lessons learned from other geographies into the design and implementation of these laws.
- Work with technology actors to ensure that they understand and will abide by these principles.
- Consider developing shorter-term ‘codes of conduct’, which can achieve outcomes

similar to legislation but with shorter lead-time.

- Invest in strong data protection measures and abide by their own policies as part of their data infrastructure investments and data collection efforts.

Donors can play an important advisory and technical assistance role in these efforts.

We recommend that donors:

- Help governments and legislators develop data policies by offering technical assistance and funding for such initiatives.
- Consider the balance of risks and returns in data privacy/security regulation. Support market development policies that ensure consumer protection while managing the downsides of overregulation.
- Familiarise government decision makers with the issues and risks inherent to capacity building and then assist their efforts to build actual capacity that attends to the technological and legal aspects of data privacy, data regulation, and cyber security. Expertise in this field is often absent today.
- Share best practices and lessons learned from other geographies.

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- Invest in research that will promote the creation and adoption of good data policies. This could include behavioural research that explores D4Ag user experience and willingness to share data in order to establish a business case for company adoption of strong privacy practices.
- Advocate for and promote greater transparency among enterprises to help fight against algorithmic bias against specific segments.

Investors serve as stewards of good data policies.

We recommend that investors:

- Prioritise privacy and consumer protection as key elements of their diligence processes.
- Help build shared infrastructure for their investees, e.g., through partnerships with cyber security firms, to help investees protect their data.

6. Invest in the D4Ag research agenda

The D4Ag space is evolving rapidly.

New approaches, business models, and ideas are continually being tested. Yet, broadly speaking, stakeholders have focused more on experimentation than on sharing insights and lessons. As the sector matures, there is a valuable opportunity to develop both a stronger set of indicators, best practices and lessons learned and a stronger community with which to share these practices.

We recommend knowledge investments in three major areas:

- **User-centric research and design.** Immersive, farmer-centric research will enhance the sector's understanding of what farmers want, how farmers are responding to existing products, what drives the adoption and use of such products, and ultimately, how offerings can evolve to increasingly generate value for farmers. This kind of research can help address the needs of
- **Better market and business model intelligence.** Case studies on successful actors – e.g., how they were set up, their revenue models, the pivots they made along their journey – will provide valuable insights into the key factors that drive success in D4Ag. Case studies on less successful examples are equally important and will allow the sector to also learn from shortfalls and mistakes. Similarly, we need continued investment in market intelligence that regularly updates and builds upon the baseline developed in this report.
- **Systematic research on impact.** We need more evidence about the impact on the ground. Impact metrics should be more standardised so we can make stronger comparisons across use cases and business models. Also, in many cases, the evidence needs to be more rigorous (e.g., driven by a third party, rather than purely in-house metrics). When collecting evidence,



underserved and marginalised groups like women. It should be part of day-to-day product design, so that enterprises build solutions rooted in the needs and preferences of their customers. While this may sound obvious, companies often overlook this step.

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it is crucial that we better understand the contribution of digital vs other business model enablers in creating the impact in question.

Donors should take the lead in advancing the research agenda.

We recommend that donors:

- Fund the proposed knowledge initiatives in conjunction with governments, D4Ag enterprises, researchers, and others as appropriate.
- Facilitate sharing of best practices and lessons learned.
- Promote greater standardisation of impact metrics and data collection practices.

Governments have an important role to play in contributing to the research agenda.

We recommend that governments:

- Open their own databases for research purposes, especially as they invest in and expand their D4Ag data infrastructure.

- Fund or co-fund investments in data collection efforts, especially those that involve large-scale data collection at the level of individual farmers.
- Integrate emerging lessons and findings into their own plans and programmes.

We expect that **investors** will primarily be consumers of knowledge products, but they can still play an important role in generating and sharing knowledge.

We recommend that investors:

- Fund or co-fund market-building research initiatives, for example by partnering with governments that test and bring new technologies to market.
- Contribute to broader sector efforts by sharing (even confidentially) important information about their D4Ag investments – including information that may not be public, e.g., amount and mix of funding and strategic plans.
- Transfer knowledge across and between regions in which they work.



7. Create an alliance of key stakeholders to promote greater investment, knowledge sharing, and partnership building

Strong leadership and improved partnerships between sector actors are needed in order for the opportunities identified in this report to come to

fruition. Given the fragmented nature of existing initiatives, this is not likely to happen automatically. Rather, D4Ag needs a strong alliance and a knowledge clearing house to drive the sector.

We recommend establishing such a D4Ag alliance with the following key objectives:

- Attracting greater investment in the D4Ag sector, for example by supporting pipeline generation and facilitation.
- Facilitating deeper relationships and collaboration amongst D4Ag actors.
- Helping connect various aspects of the ecosystem together, for example by linking agricultural technology innovation to big technology players or helping link agronomy insights to various actors' D4Ag efforts.
- Building knowledge and producing periodic reports about the state, progress, and challenges of the D4Ag sector.
- Developing capacity – especially among governments, farmers, and young entrepreneurs – to realise the potential of D4Ag.
- Developing indicators for monitoring/tracking progress and reporting to the key stakeholders through regular convening.

For the alliance to be successful, we recommend a partnership between governments, donors, investors and other value chain actors who are dedicated to advancing inclusive, sustainable D4Ag across Africa and beyond. Members must make a public

commitment to this initiative, inform its mandate and priorities, offer resources for its operations, and serve as active participants and contributors to its agenda and activities. They should also back and support the priorities and recommendations of the alliance – where possible and in line with their own priorities – and serve as champions for its efforts. The success of similar alliances in other sectors, e.g., in health, highlights the promise of such an approach.

We also recommend that the alliance invest in building a deep membership base that is excited about its mission and offering. Beyond the core group of sponsors, the alliance will need to attract the interest of the broader sector: non-sponsors, enterprises, farmer organisations, etc. These groups will play important roles as active participants and contributors to the alliance's efforts and will serve as consumers and beneficiaries of its knowledge products and convenings.

In order to ensure its relevance for the sector, the alliance should maintain a deep understanding of D4Ag, the needs and perspectives of farmers, and the priorities of the full ecosystem of actors, especially regional and local priorities.

It should incorporate those priorities as it defines its mandate and should revisit these priorities on an ongoing basis so that its efforts remain complementary to existing efforts on the ground. As such, we recommend that the alliance be nimble in its approach and capable of adjusting to the dynamic needs of the space.

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Strong leadership and improved partnerships between sector actors are needed in order for the opportunities identified in this report to come to fruition.”



ANNEX 1 COUNTRY CASE STUDIES



ETHIOPIA³⁸²

Ethiopia has shown that a state-led development model for D4Ag can deliver rapid scaling. In the long term, however, the sector will likely require greater private sector involvement to realise its potential.

Key D4Ag statistics:

Total users of solutions headquartered in Ethiopia³⁸³	5 million
Number of solutions	4 (headquartered); 29 (with a presence)
Proportion of users that are women³⁸⁴	17%
Most common primary use case of solutions	Advisory services
Government role	Sole operator. All solutions are government-provided.

Snapshot of D4Ag solutions:

 Advisory services	   
	   
 Market linkage	  
 Supply chain management	  
 Financial access	   
 Macro agriculture intelligence	  

Context: Agriculture in Ethiopia

More than 80% of Ethiopia's population live in rural areas, where agriculture serves as their main source of income. The sector accounts for 45% of GDP, almost 90% of exports, and 85% of jobs. The vast majority engage in agriculture as subsistence farmers. The country's main crops are coffee, pulses, oilseeds, maize, wheat and teff. Yields remain low, even by Sub-Saharan African standards. The government has made tackling the country's food insecurity a core development priority. As part of this effort, it introduced a series of reforms meant to increase agricultural yields and put an end to unsustainable farming practices that lead to environmental degradation and affect agricultural productivity.³⁸⁵

The state of D4AG in Ethiopia today

Ethiopia's state-led approach to the introduction of D4Ag offers important advantages for scaling. Ethiopia established the Agriculture Transformation Agency (ATA) in 2010 as a strategy and delivery-oriented government agency to help accelerate the growth and transformation of their agriculture sector. Through the ATA, the government designs and in some cases implements interventions. The government is the sole distributor and price-setter of inputs to farmers (e.g., fertiliser and seeds), and employs the largest network of extension workers in Africa. Ethiopia's only mobile network operator, Ethio telecom, is state-owned, as are major D4Ag solution providers (others work in close partnership with the ATA). Ethio telecom

CTA



responds to Ethiopia's digital and agricultural transformation agendas and helps them coordinate D4Ag efforts. A centrally-organised approach to some degree also helps Ethiopia encourage farmers to align their farming practices and outputs. This leads to crop intensification and efficiency gains through economies of scale.

Solution providers have developed effective ways to work around the country's digital challenges. The 8028 Farmer Hotline is a prime example. This platform offers farmers free advisory services via interactive voice response (IVR)/short message service (SMS).³⁸⁶ Three factors buoy its success. First, by utilising text and IVR, the service offers a much wider reach than internet-based solutions. In Ethiopia, just 4% of the population has access to the internet and digital literacy among farmers is nominal. To address these challenges the 8028 service invested heavily in agents and in the deployment of its lines. They also developed a platform with information that digitally-savvy intermediaries can share via existing networks (e.g., extension workers, teachers, health workers, or just popular farmers in their region).

Outlook

More flexible regulation could further expansion of the D4Ag industry. So far, the government has achieved impressive results under their growth strategy. However, at present, providers are barred by law from charging farmers for advisory services. Similarly, tight strictures regulate who can provide financial services. This constrains the growth of mobile money in the country.³⁸⁷ More generally, businesses that offer D4Ag solutions via official channels report that the government's deep involvement in the sector constrains private sector development. Recognising the limitations of public-only models, in February 2019, Ethiopia announced that it will privatise their state-owned telecommunications company and allow private

operators to enter Ethiopia's telecom market. New rules will permit firms that are not 100% government-owned to issue SIM cards and man operation towers. More such reforms are needed to reshape policies and laws that discourage competition. Government and donor-backed investments have supported the rapid and substantial development of D4Ag in Ethiopia, but such investments will not likely be sufficient to build a competitive, sustainable sector in the long term. Policy reform could encourage more private operators to enter the fray. This would increase the number of solutions on offer and, in turn, the breadth of products that farmers could access.

Lessons



- ▶ Simple workarounds can circumvent digital barriers to D4Ag scale-up. For example, phone-based solutions can overcome low internet penetration, and low digital literacy rates among farmers can be counteracted by heavy investment in agents who can address their queries.
- ▶ State-controlled D4Ag advisory services can help align farmer activities and in doing so, achieve economies of scale.
- ▶ Central coordination of D4Ag scale-up can help align digital and agricultural development agendas, as demonstrated by the ATA, which controls all aspects of digital agriculture in Ethiopia. This is distinct from countries like Senegal, where digital and agricultural decision-makers in government work less collaboratively.



GHANA

Ghana has created an environment that is well suited to rapid D4Ag scale up, but existing solutions must be tweaked before their full impact potential will be achieved.

Key D4Ag statistics:

Total users of solutions headquartered in Ghana ³⁸⁸	1.6 million
Number of solutions	28 (headquartered); 57 (with a presence)
Proportion of users that are women ³⁸⁹	30%
Most common primary use case of solutions	Nearly even mix across four use cases: advisory services (7); market linkage (7); supply chain management (6); data intermediary (5)
Government role	Active promoter of D4Ag via agricultural and digital policies.

Snapshot of D4Ag solutions:

 Advisory services	     
	      
 Market linkage	     
	    
 Supply chain management	     
	  
 Financial access	    
	   
 Macro agriculture intelligence	    
	  



Context: Agriculture in Ghana

Agriculture accounts for 18% of Ghana's gross domestic product (GDP).³⁹⁰ The percentage of agriculture's contribution to GDP is expected to decrease, while non-agricultural services and other industrial sectors are projected to expand. At present over half of the country's workforce (52%) engages in agriculture.³⁹¹

Crop farming is economically more important than livestock production, with cocoa, oil palm, coffee, and rubber ranking as the most significant crops.³⁹² In recent years, growth in non-agricultural services and other industrial sectors has outpaced that in agriculture.

Agriculture, nonetheless, continues to grow at a strong pace (e.g., 8.4% in 2017), thanks, in part, to government support via a number of interventions, including, as an example, the 2017–2019 'Planting for Food and Jobs' Campaign (PFJ).

The state of D4Ag in Ghana today

Ghana's government created an environment that helps D4Ag thrive.

Between 2013 and 2015, Ghana introduced a series of regulatory reforms intended to help expand the use of mobile money in the country. These reforms led to a rapid rise in the adoption of related services and helped open people to the use of digital products and services. Since then, large agribusinesses like Yara have encouraged farmers to adopt mobile money by requiring farmers who work with them to open mobile money accounts. In addition, the recent insecurity of some of Ghana's trade neighbours (e.g., Burkina Faso, Niger) has pushed more farmers to use mobile money – a safer alternative to in-person cash payments. Moreover, the government has introduced a range of initiatives intended to support the use of innovative technologies specific to agriculture. These include the launch of: (1) 'Planting for Food and Jobs', an e-registration platform for farmers with 577,000 farmers registered and with 202,000 farmers participating in 2017 and 677,000

in 2018;³⁹³ (2) an electronic, agricultural input distribution system with barcodes that allows the government to more quickly detect problems like low-yield seeds and poor fertiliser. Policymakers have also set themselves the ambitious target of registering every cocoa farmer in the country.

A number of companies have taken advantage of the supportive environment and built valuable D4Ag services in Ghana.

Outlook

The priority now is to ensure D4Ag solutions reach underserved populations to deliver real impact.

Many farmers are illiterate, so providers are starting to roll-out services that work around this. Similarly, Farmerline and Esoko now provide IVR services that cater to the country's linguistic diversity by offering services in local languages. Still, some regions remain too unproductive for D4Ag solutions providers to enter, either because soil quality is too poor, transportation infrastructure is weak, or insecurity is high.

D4Ag should be used to address barriers to access to credit that farmers, particularly low-income farmers, face.

Such farmers enjoy using D4Ag to access financial services, but few use services beyond mobile payments. Credit remains too expensive for most farmers – 28% interest rates were quoted as recurrent by one expert we spoke to. Although some D4Ag providers have encouraged banks and investment companies to help reduce this cost of debt, little progress has been made. D4Ag may be able to promote farmers' access to credit indirectly. For example, by improving land rights data, D4Ag can increase farmers' ability to use their land for collateral when borrowing. At present an initiative funded by the Omidyar Network is supporting capacity building at government levels in the use of drone technology for land tenure adjudication. This project also extends to the Philippines and Colombia. It aims to build evidence in each country for the effective



utilisation of drones for property mapping and seeks to demonstrate how drones can be deployed for cadastral surveying on a global scale. In addition, Meridia, the leading D4Ag innovator in digitally-enabled land registration, has digitally surveyed and mapped thousands of smallholder farms in Ghana starting in 2017, and has helped issue over 5,000 legal land documents – documents that are crucial to helping smallholders leverage the economic potential of their land, a model with potential across Africa.

Forthcoming D4Ag solutions have the potential to help or harm women’s empowerment in the country. Solution providers must design products that are gender positive. For example, the digitisation of land rights records will lead to

massive impact gains for farmers, but if only landowners, who tend to be men, and not other household members are recorded, it may also reinforce gender inequality in land ownership. Similarly, women who work in agriculture in Ghana tend to participate more as retailers in local markets. D4Ag solutions could render many of these jobs obsolete. Firms like Esoko Ghana are demonstrating how to counteract the potentially negative gender effects of such innovations by, for example, actively hiring women to be call centre operators.

Market linkage solutions are likely to be most useful for farmers positioned to service multiple markets. Because they lack transport options to reach a wider range of potential buyers, most smallholder farmers deal with one local produce buyer only. The impact potential of market linkage D4Ag solutions is therefore limited to larger players and those dealing with multiple markets (e.g., aggregators), who benefit from having a better understanding of when and from where products are coming.

Farmerline



Lessons



- ▶ Mobile money is a key enabler for D4Ag service providers, because it helps farmers and the broader population trust and understand digital products/services.
- ▶ D4Ag has the potential to increase farmers’ access to credit, for example, by improving their ability to use their officially adjudicated land as collateral.
- ▶ Market linkage products are most useful to farmers with the means of transport to work with a range of markets.



NIGERIA

Nigeria provides an example of how the private sector can drive an innovative digital transformation of agriculture, but it also illustrates how this development can leave more rural and vulnerable farmers behind.

Key D4Ag statistics:

Total users of solutions headquartered in Nigeria ³⁹⁴	0.5 million (another 7 million in Cellulant database via former Cellulant/SES e-wallet subsidy programme).
Number of solutions:	46 (headquartered; 83 (with a presence))
Proportion of users that are women ³⁹⁵	20%
Most common primary use case of solutions	Market linkage
Government role	Supportive, but private sector plays a heavy role in steering the direction of D4Ag.

Snapshot of D4Ag solutions:

 Advisory services	         
 Market linkage	               
 Supply chain management	 
 Financial access	        
 Macro agriculture intelligence	



Context: Agriculture in Nigeria

Agriculture accounts for 20% of Nigeria's GDP, compared to an average 16% of GDPs across Sub-Saharan Africa more generally. The sector employs approximately 26 million people, representing about half of all jobs.³⁹⁶ More than 80% of these people

are smallholder farmers.³⁹⁷ Nigeria's primary crops are rice and cassava, but the country is also well suited to become a leading exporter of more valuable commodities like cocoa, groundnut, and palm oil. Yet, according to a recent report from Nigeria's National Agricultural Extension and Research Liaison Service (NAERLS), the overall farm yield in Nigeria is well below the African average.

Arne Hoel, World Bank



Nigeria is still a net importer of some of the crops the country is best suited to produce, such as rice and tomatoes. Even though the government is anxious to slow Nigeria's import of rice, these imports are expected to increase by 13% in 2019 making Nigeria the world's second largest rice importer.³⁹⁸ In response to the increasing imports as well as to the insufficient infrastructure in rural areas, the government, in recent years, launched policies to liberalise the sector and attract more private investment. This encouraged many businesses, including D4Ag solution providers, to enter the market.³⁹⁹

The state of D4AG in Nigeria today

Despite increasing investment in Nigeria's agriculture, most D4Ag players remain small. Nigeria has one of the most active D4Ag markets in Africa as measured by count of solutions but few players, even those that are well-known and regarded – have reached scale. For example, FarmCrowdy serves around 7,000 farmers and the Crest Agro-processing project, supported by CardinalStone, accounts for about 5,000 registered farmers. In our data analysis, only one solution provider headquartered in Nigeria had more than 50,000 users (Hello Tractor, with 250,000 registered farmers). This may be because the players are mainly focussing on larger farms in tighter value chains or because expansion among rural farms is difficult. Few companies in Nigeria approach the digital transformation of agriculture through a lens of inclusion and more vulnerable farmers face fundamental challenges that make them unattractive for most private sector players. But this is also true everywhere. What differentiates Nigeria from other D4Ag ecosystems, like Rwanda and Ethiopia, is that the government and NGOs/foundations have yet to play a major role in filling service gaps to promote inclusion.

Outlook

The scalability of these existing solutions remains uncertain.

The D4Ag providers that have emerged in recent years tend to focus on more specific points of the agriculture value chain: Hello Tractor aggregates demand for tractor services across Nigeria through a wide network of extension agents; AFEX set up storage facilities for grains across Nigeria and uses Binkabi's blockchain technology to improve farmers' access to credit through the provision of electronic warehouse receipts; and FarmCrowdy provides capital for specific on-farm projects. Such focused approaches do not offer the same opportunity to generate multiple revenue streams for their companies, but, because the service offerings are simpler, they are easier to adapt to new markets and could, therefore, be easier to scale. These D4Ag firms among others have set ambitious growth targets for themselves – Hello Tractor seeks to have 15 million users within five years. Yet, scaling at this pace will depend heavily on the sectors' ability to attract private sector capital, and, according to experts in the sector, most companies will be hard pressed to deliver returns and risk profiles that can compete with similar investments, especially those outside of Africa (e.g., in Southeast Asia).

Growth in D4Ag will concentrate on solutions that serve farmers who are more profitable in the short-term, leaving vulnerable populations behind.

Over the next 3–5 years, the most successful D4Ag firms in Nigeria will likely be the ones that target the larger farms, the more well-connected farms, and the farms closer to large off-takers. Small farmers in Nigeria, such as those in less fertile northern regions and those farming perishable goods, are more likely to be left behind than their counterparts in other countries such as Ethiopia and Rwanda where governments have stepped in to fill the gaps left by private sector players.



Weak fundamentals prevent many smallholder farmers from benefiting from D4Ag. Agriculture experts in Nigeria, including agribusinesses, investors, and D4Ag companies, say there is a need to ‘get the basics right’ before many of the smallholder farmers are ready for a digital revolution led by the private sector. Until their essential needs are addressed, these farmers will not be able to deliver the quality and scale of output that is attractive to private sector companies.⁴⁰⁰ Barriers include: (i) irrigation levels that are well below the average in Africa with less than 2% of all cropland in Nigeria under irrigation; (ii) last-mile infrastructure that ranked among the worst in the world in the 2018 Global Competitiveness Report from the World Economic Forum;⁴⁰¹ and (iii) poor digital connectivity – despite high levels of mobile penetration, the vast majority of farmers are either disconnected or only have access to an unstable 2G connection.

The government can address these challenges by investing in agriculture’s fundamental necessities and partnering with the private sector to drive more inclusive investments. Public infrastructure for agriculture remains in dire need of government funding. The government recently collaborated with IFAD on a major roads-building project in the north of the country. With just 15% of roads in the country paved, more investments like this are urgently needed. The government also needs to partner with private sectors operators to: (1) use PPPs to

achieve scale – other sectors demonstrated the potential of PPPs to do this, for example, in 2017, the government partnered with the Venture Garden Group to launch the Health Pay Platform; and (2) fill investment gaps in D4Ag left by private sector investors – most private capital is not patient enough to support investment in inclusive solutions that can serve vulnerable and less lucrative customer groups, but philanthropic and government investors are better positioned to do this.

Lessons



► Service providers who focus on less sophisticated D4Ag solutions with only one revenue stream may be able to scale more easily, since it is easier to adapt their offerings to new markets. But scale does not equal use and it may be challenging to make money without offering greater value add to farmers.

► While important to encourage innovation by the private sector, governments also need to play a role in promoting impact and sufficiently regulating the sector. Otherwise, the result is a landscape littered with many solutions that do the same thing, with many providers paying limited attention to impact.



SENEGAL

D4Ag could accelerate Senegal's agricultural transformation but greater policy support and help from incubators/early stage investors is needed for it to take off.

Key D4Ag statistics:

Total users of solutions headquartered in Senegal ⁴⁰²	400,000+
Number of solutions	15 (headquartered); 43 (with a presence)
Proportion of users that are women ⁴⁰³	10%
Most common primary use case of solutions	Advisory services and market linkages
Government role	Government has yet to put its full weight behind D4Ag.

Snapshot of D4Ag solutions:

 Advisory services	        
 Market linkage	      
 Supply chain management	      
 Financial access	
 Macro agriculture intelligence	



Context: Agriculture in Senegal

The government has made agriculture a central priority of its development plans for the country, but has yet to throw its weight behind D4Ag. The agricultural sector is of critical importance to the economy – it employs over half the workforce (53%). However, it accounts for just 16% of the GDP.⁴⁰⁴ Senegal's primary crops are rice and maize, which are organised in loose value chains, and millet and fish, which have value chains that are slightly tighter (but still not ideal).⁴⁰⁵ Compounding the challenge of insufficient value chains, land cultivation is lacking – less than 5% of the country's arable land is irrigated.⁴⁰⁶ Policymakers are focused broadly on agricultural transformation (i.e. mechanisation and commercialisation) as a way to drive economic growth. However, while the government has made large public investments into agriculture (~10% of GDP per year), little of this has gone toward D4Ag.⁴⁰⁷

The state of D4AG in Senegal today

D4Ag has yet to take off in Senegal, because farmers are fragmented and have low levels of access to and trust in digital products. Few successful examples of D4Ag solutions have emerged in Senegal to

date (MyAgro is a rare success story). Ninety one percent of farmers own less than 10 hectares. D4Ag solutions are less affordable to farmers working on this scale. Moreover, because of Senegal's underinvestment in cell towers and other infrastructure, rural populations lack solid access to 2G/3G coverage, mobile phones, or internet. Farmers' attitudes towards digital products and services pose another barrier for D4Ag. Loose data privacy laws have eroded their trust in these solutions. Furthermore, after years of donors providing these solutions at no cost, farmers' willingness to pay is low, even if they do recognise the value in them.

Through their unwillingness to fully support D4Ag, policymakers hinder its ability to scale-up. Tight regulations discourage private actors from choosing to locate in Senegal rather than in a more favourable environment. Corruption and lack of transparency have held back the digital transformation of several aspects of agriculture in the country. Reforms are badly needed – for example with regard to the management of land rights and the state's distribution of fertiliser to farmers. Country experts say the lack of government action to support D4Ag is partly due to a limited awareness of the long-term efficiency gains it could yield for state-funded projects.

Xaume Olleros, RTI.



Outlook

Senegal's D4Ag start-ups need a more supportive ecosystem of incubators and early-stage investors to help them get off the ground.

Mentorship and seed funding are in short supply in the sector. There are limited incubators and few angel investors or VC firms focused on Senegal. In addition to this lack of support, language barriers discourage many would-be investors (who are often primarily English-speaking) from entering Senegal and other francophone markets in the region. The shortage of capital has prevented many high-potential firms (e.g., Mlouma and Monobi) from growing beyond the start-up phase. Additionally, several solutions have failed because their designers tried to introduce 'copy-and-paste' models from other markets, rather than investing sufficiently in customisation for local Senegalese contexts. A few, rare success stories show that incubation or early stage investment can work well. For example, Orange incubated Bayseddo, a platform that facilitates agricultural production by crowdsourcing finances in Senegal, which CTA recognised as one of the winners of the CTA-sponsored Pitch Agrihack awards in 2017.

Cooperatives could provide a good network through which to grow D4Ag.

Cooperatives are well coordinated and have deep relationships with their local communities. They are trusted intermediaries, so farmers are more likely to use products, including D4Ag, provided by them.

The private sector will only be able to achieve so much alone. Advocacy and policy reforms are needed to drive more D4Ag momentum within government. NGOs and other organisations focused on social impact must make a clearer case for D4Ag scale-up to decision-makers in government. With greater political will, reforms can follow the example of Nigeria and other countries in the region with policy environments that are more welcoming to

potential investors. Specifically, better data privacy laws are needed to reassure D4Ag users that their personal data will be kept safe. Also, more investment in the country's ICT infrastructure (e.g., mobile towers) is required to lay the much-needed foundations upon which the private sector can build.

Lessons



- ▶ D4Ag is harder to scale up in countries where farmers are highly fragmented, and this is exacerbated by limited country support
- ▶ Cooperatives are a good stakeholder to work with when looking to build trust with farmers.
- ▶ Expertise is needed to translate successful solutions from one market to the next. Incubators and early-stage investors are often well placed to provide this. Translation is also not a game of pure replication and can require significant effort into learning and adapting to local market conditions and strong investments in user-centric design.

“

Cooperatives are well coordinated and have deep relationships with their local communities. They are trusted intermediaries, so farmers are more likely to use products, including D4Ag, provided by them. ”



KENYA

D4Ag has flourished in Kenya. This success will continue if ecosystem players work together to manage risk.

Key D4Ag statistics:

Total users of D4Ag solutions headquartered in Kenya⁴⁰⁸	9.0 million
Number of solutions:	64 (headquartered); 114 (with a presence)
Proportion of users that are women⁴⁰⁹	28%
Most common primary use case of solutions	Market linkage (22); Advisory services (19); Financial Inclusion (22)
Government role	Supportive and forward-looking.

Snapshot of D4Ag solutions:



Advisory services






















Market linkage













Supply chain management










Financial access














Macro agriculture intelligence










Context: Agriculture in Kenya

Agriculture accounts for 34.6% of Kenya's GDP. There are 16 million smallholder farmers in the country. More than three-quarters of Kenyans make some part of their living in agriculture. The sector's primary crops are: maize, coffee, and tea. Yields in the country are about 12% higher than Sub-Saharan African averages but agricultural productivity has stagnated in recent years, maximum yields have not been achieved, and only 20% of land is suitable for farming. Moreover, drought and disease continue to pose a risk to food security for many vulnerable populations in the country.⁴¹⁰

The state of D4Ag in Kenya today

Kenya has more D4Ag enterprises and users than any other Sub-Sahara African country. Over 100 solutions are in the market – 31% of operators on the continent have locations in Kenya. And 20–30% of Kenyan farmers are touched by more than one digital solution. The projected revenues of D4Ag players in Kenya is \square 18-35 million in 2019. Large and fast-growing examples include WeFarm (1.4 million users), iCow (0.8 million users), Pula (0.6 million users),

KCB/Mobigrow (0.4 million users), and PAD (0.4 million users).

Kenya's digital-friendly environment has helped D4Ag flourish. D4Ag benefits from Kenya's high levels of connectivity, mobile phone usage, and data transparency. Safaricom's M-Pesa and the rise of mobile money over the last decade has made Kenyans more comfortable with digital products, particularly for transactions. An adaptable regulatory environment enhances the relatively quick uptake of mobile money.⁴¹¹ Nairobi's emerging community of ICT entrepreneurs has also strengthened growth. Additionally, Kenyans have relatively high levels of basic literacy, especially among youth. This allows enterprises to use SMS rather than more-expensive IVR when communicating with users.

The presence of mobile money has increased interest in D4Ag among businesses. Our research found that half of venture capital/private equity investment in AgTech in Sub-Saharan Africa occurs in Kenya. The ability to move money digitally is important for most revenue-seeking enterprises and private investors. Donors/NGOs tend to fill the gaps by supporting those solutions that do not focus on mobile money.

Neil Palmer, CIAT



Outlook

The outlook for D4Ag in Kenya looks good, with bundled services best positioned to grow.

Commentators are optimistic about the growth potential of D4Ag in Kenya. Private investment and donor support are expected to continue. Broader trends are also positive. For example, more young people – who drive Kenya’s increase in digital literacy – are expected to stay in rural areas. Amid such trends, more providers will follow enterprises like DigiFarm, which provides farmers with bundled services.⁴¹² Providers that offer more than one solution will likely capture more revenue in a competitive market where farmers have limited expendable income.

While the overall forecast is positive, experts in the field have advised caution.

Some experts on Kenya’s agriculture are concerned about the speed at which extension services have decreased in recent years. This view is informed by, for example, the fact that farmers respond much better to extension workers using digital tools, rather than digital-only services. To mitigate risk, the roll-out of new D4Ag technologies should be accompanied by strong human intermediation along with close monitoring and evaluation.

Collaboration between D4Ag stakeholders can build a thriving sector that works for all users.

To help coordinate ecosystem actors and avoid duplication of effort, solutions must combine familiar faces, technology, and business knowledge. Partnerships between enterprises, agribusinesses, NGOs, banks, and others can

enable this. For example, the agricultural supply chain, iProcure, is partnering with existing agricultural dealers in Kenya. Meanwhile, the growth and expansion of such platforms as iKilimo and iCow has been hampered by the lack of strong partnerships among stakeholders and by weak evaluation and monitoring.⁴¹³ Intermediaries can play an important role in encouraging partnerships. AgriFin has become an early leader in this effort, hosting networking opportunities for entities active in agriculture finance.⁴¹⁴ Additionally, as in some other countries we profiled, policies around data privacy and customer protection have yet to be developed fully.⁴¹⁵ Given the size of its D4Ag space, this deficiency could present a bigger problem for Kenya than other countries and should be a focus area in coming years.

Lessons



- ▶ Mobile money and a digitally savvy population enable rapid scale-up of D4Ag solutions.
- ▶ Bundled services are better positioned to capture revenue opportunities in consumer markets primarily consisting of farmers with low expendable income.
- ▶ Farmers are wary of fully digitalised D4Ag services. Kenya highlights the continued value of human intermediation (agent networks) in D4Ag.



RWANDA⁴¹⁶

Rwanda's government has led remarkable growth in D4Ag. It is now shifting toward a more market-driven approach to scaling up solutions.

Key D4Ag statistics:

Total users of solutions headquartered in Rwanda⁴¹⁷	3.5 million
Number of solutions	8 (headquartered); 44 (with a presence)
Most common primary use case of solutions	Advisory services
Government role	Active promoter and now moving from market-player toward market-enabler.

Snapshot of D4Ag solutions:

 Advisory services	     
 Market linkage	      
 Supply chain management	  
 Financial access	      
 Macro agriculture intelligence	    



Context: Agriculture in Rwanda

Agriculture accounts for a little more than 30% of Rwanda's GDP.⁴¹⁸ Out of Rwanda's population of more than 12 million people about 70% are dependent on subsistence farming.⁴¹⁹ Due to the high population density of the country, the average size of farms in Rwanda is small – between 0.30 and 0.70 hectares.⁴²⁰ Tea and coffee are the country's major export products, while plantains, cassava, potatoes, sweet potatoes, maize, and beans are among the crops with the highest yield. Government agricultural policy has focused on a number of priorities in recent years: low productivity in the agriculture sector, the risk posed to Rwanda's subsistence farmers by their high-reliance on rain-fed produce, and the high fragmentation of crops across the county.⁴²¹

The state of D4Ag in Rwanda today

Rwanda has supported remarkable growth in D4Ag by investing in large-scale digital hardware and systems. The government has digitised its national identity card system, land titles, platforms to access government services (*Irembo*), and social registry (*Ubedehe*). Rwandans' participation in these programmes has increased familiarity with digital technologies, priming them to use digital

solutions in agriculture. Physical infrastructure has also contributed to this enabling environment. For example, the government has prioritised the installation of fiberoptic network connections in all districts.⁴²²

CTA's ICT4Ag international conference in Kigali

CTA hosted an international conference in Kigali, Rwanda, in November 2013, that focussed on the use of ICT in agriculture. Over 400 people attended, 'to explore the possibilities that ICT can provide in agriculture and to develop new solutions that can improve the day-to-day operations of Africa's millions of farmers'.⁴²³ The conference included a number of sessions on ICT4Ag-related topics, a hackathon, and a "plug and play day" – during which numerous digitally-enabled solutions for agriculture were presented to attendees.⁴²⁴ This conference set the stage for the ICT4Ag sector in African, Caribbean and Pacific countries to grow and attract international attention.⁴²⁵ The subsequent advancements have now equipped Rwanda to move from ICT4Ag to D4Ag and to transition from government reliance to sustainability.

P. Kimeli, CCAFS



To attract D4Ag investment, the government has begun to consolidate Rwanda's fragmented agriculture sector, but this may only help larger farmers.

The government has consolidated farms based on agro-climatic positioning, which has significantly increased the average farm size (previously it was just 0.2 hectares). It also organised farmers into cooperatives and sub-national markets. For example, 350,000 farmers were divided into 300 districts, each of which has a designated coffee aggregator who purchases coffee. D4Ag enterprises tend to reach farmers via such aggregators so these government-led steps make Rwanda a more attractive country for D4Ag activity and allow D4Ag firms to serve larger groups of aligned farmers who have shared paths to market. We have yet to see clear evidence of the impact of this consolidation on farmer productivity, but some experts assert that it tends to help only farms that are above average in size.⁴²⁶

Donors and NGOs have also supported efforts to scale-up D4Ag in Rwanda.

FAO chose to pilot their new initiative, Agricultural Services and Digital Inclusion in Africa, in Rwanda and has developed four smallholder farmer-focused digital products and services to launch in 2019. One Acre Fund created and is beginning to trial a digital enrolment system that runs on USSD. This application is intended to increase adoption by allowing farmers to self-enroll with limited assistance from a field officer. This could dramatically increase the field officer's management capacity from an average of 300 farmers to as many as 2,500 farmers. One Acre Fund also collaborated with the Rwandan government in farmer mobilisation and registration in the Smart Nkunganire System, 'a supply chain management system built by BK TecHouse Ltd in collaboration with Rwanda Agriculture and Animal Resources Development Board to digitalise the end-to-end value chain of the agro-input subsidy programme'.⁴²⁷



In response to this ecosystem-building, a few D4Ag firms have located operations in Rwanda but private investment remains low.

N-Frnds records farmer transactions to incentivise soft loans from banks, charging the bank for each loan obtained by leveraging its data. Kumwe developed internal digital tools to track market transactions and optimise transportation from farm to market. Both Kumwe and N-Frnds are generating healthy revenues and running sustainable businesses, but they need capital and broader markets to scale. Private investors, namely, venture capital (VC) and private equity (PE) firms, have not yet demonstrated much interest in this space. On the other hand, Charis Unmanned Aerial Solutions (UAS) Ltd., a youth-led startup incorporated in 2014 and now employing 15 youth, offers drone-based services to various industries, including agriculture, and is growing fast. It now provides services to private sector and government agencies in Rwanda, opened a satellite office in Côte d'Ivoire, and also executes contracts in neighbouring countries. The company attracted foreign investment which allowed further expansion.

Simona Siad, IFAD



Rwanda has pledged to address the need for greater investment from the private sector. It introduced tax exemptions on ICT and agriculture imports, access to land that favours agribusinesses, and access to extensive data about farmers. In late 2018, the Rwandan Ministry of Agriculture and Rwanda Development Board announced the creation of a ‘one stop centre’ for investors committed to increasing annual investment in agriculture to €80 million.⁴²⁸ Toward the same end, the government also strengthened its focus on the expansion of innovation and skill building in Rwanda. Knowledge Lab (kLab) is an ‘open technology hub’ that supports entrepreneurs with mentorship, networks, and more.⁴²⁹ In 2014, CTA collaborated with kLab and others on the Rwanda National ICT4Ag Hackathon.⁴³⁰ Carnegie Mellon, Andela University, and African Leadership University have talent centres in Rwanda that build needed local skills. Additionally, the €90 million Rwanda Innovation Fund plans to “support between 20 and 25 ICT companies, of which at least 10 will grow into \$50 million worth of corporation in 10 years.”⁴³¹ The government will contribute 30% of the capital needed for this fund.⁴³²

To become viable, Rwanda’s D4Ag firms may need to expand into new countries with less receptive markets. Rwanda’s small size makes it difficult for firms operating there to hit the scale needed to become profitable. The natural response is to expand into nearby countries. Uganda, Zambia, and Tanzania are likely targets, but these markets are likely to present new barriers to overcome – they are mostly cash-based economies; their governments are less pro-D4Ag; their

populations are less digitally savvy; and their agricultural sectors are fragmented. The result is that many companies are hesitant to expand into these neighbouring geographies (Uganda and Zambia perhaps more so than Tanzania).

To help its D4Ag firms, Rwanda should look to coordinate its D4Ag policy with other countries in the region.

Regional integration has served Rwanda’s economic growth well in the past decade. Rwanda now has an opportunity to promote digital technology as part of this regional integration, and given their sharp dependence on agriculture, D4Ag should be a central component.

Lessons



- ▶ The Rwanda example highlights that active government investment in the broader enabling environment has strong impacts on innovator interest in building D4Ag businesses in country. Strong, public declarations of commitment to building out ICT infrastructure and PPP models can stimulate investor demand, as well.
- ▶ D4Ag players operating in small countries will likely need to expand across borders to reach financially sustainable scale. That likely requires more regional cooperation.
- ▶ The consolidation of farms helps attract D4Ag investment but may increase the productivity of large farms only, rather than smaller farms and more marginalised groups.



SAHEL

The analysis of the G5 countries (Niger, Burkina Faso, Mali, Chad and Mauritania) was not done with the same level of detail as the Senegal case study. Nevertheless, the intention is to give a flavour of the specific challenges in these countries based on desk study, interviews, and responses to a survey. The Sahel countries face unique challenges to D4Ag scale-up, making them different from neighbouring countries.⁴³³ Solutions, however, could make a large impact in the region, and a few early movers have provided precedents to potential entrants, even under difficult conditions.

Key D4Ag statistics:

Total users of solutions headquartered in Sahel⁴³⁴	5.7 million
Number of solutions	28 (headquartered); 92 (with a presence)
Most common primary use case of solutions	Advisory services.

Snapshot of D4Ag solutions:

Niger



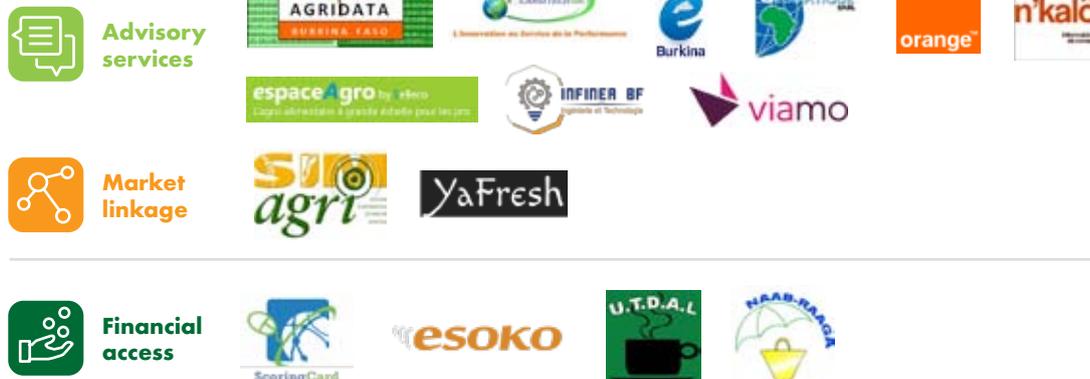
Mali



Chad



Burkina Faso



Context: Agriculture in the Sahel

As mentioned above, agriculture in the Sahel region faces a number of significant challenges that make D4Ag scale-up and agricultural transformation potentially more difficult. Various factors make farming in the region less profitable and, in turn, reduce the viability of D4Ag solutions. Loose commodity markets do not lend themselves to the implementation of standardised digital solutions but may benefit most from the price transparency they could create. One of the main questions the region faces is how Sahelian agriculture can innovate and develop to meet the vital needs of a growing population in the face of climatic hazards.

Governments in the Sahel have made agriculture a central priority of their development, but D4Ag is not yet a priority for all. Recent funding for agriculture in the Sahel by the Organisation for Economic Co-operation and Development (OECD) countries exhibits significant variance.¹⁹⁴ Similarly, bilateral commitments during the last five years by the Development Assistance Committee (DAC) countries to the agriculture sector of Senegal, Mali, Niger and Burkina Faso (€85 million, €95 million, €55 million, and €58 million, respectively)

was much higher than to commitments made in Chad and Mauritania (€8.5 million and €7.3 million, respectively). It is not possible to estimate what proportion of these commitments is designated for digital, but it is believed to be very low. The G5 Sahel group is launching multiple agricultural and infrastructural efforts through a rolling, three-year Priority Investment Program (PIP); many of these projects have allocations for agriculture and for telecommunication, but the majority of funding still needs to be secured.⁴³⁶ Still, broadly speaking, there have been some important improvements in IT and communications.⁴³⁷ The implementation of appropriate D4Ag could catalyse agricultural development in Sahelian countries.

The State of D4Ag in the Sahel today

Because of the level of market dysfunction in the Sahel, the potential impact of D4Ag solutions could be vast.

Isolated farmers would benefit most from digitally-enabled information sharing and advisory services but struggle to find affordable and available connectivity. It will be difficult to make D4Ag work in Sahel's loose commodity markets, but this is the kind of environment where the price transparency offered by D4Ag solutions could offer the largest benefits. Other solutions like digitally-enabled climate

Figure 37 **Characteristics of Sahelian countries, by country**

Country	Population (WB, 2017)	% rural (WB, 2016)	Mobile penetration (GSMA)	Mobile \$ total/rural ⁴³⁸
Niger	22M	80%	29% (2018)	8%/6%
Burkina Faso	20M	69%	44% (2018)	29%/27%
Mali	19M	59%	61% (2016)	24%/20%
Chad	15M	77%	30% (2016)	13%/13%
Mauritania	4M	40%	65% (2016)	3%/1%



insurance, soil mapping, water availability, and grazing guides also hold particular promise for the region. Some positive experiences illuminate the way forward (see below).

The level of D4Ag development varies considerably across the region.

Burkina Faso and Mali are significantly ahead of other countries, with 36 and 35 solutions present, respectively. Niger has less than half this amount, 14, whereas Chad has six and Mauritania has only one.⁴³⁹ These figures largely mirror how connected each country's rural populations are. For example, almost 40% of Burkina Faso's rural population has access to a mobile phone or the internet, but less than 15% of rural populations in Niger, Chad and Mauritania have such access. Nevertheless, interviews indicate that connectivity is not perceived as a huge issue, even for those working in remote areas.

However, the state of IT infrastructure at government ministries – dated systems that lack internet connection and have weak security features – presents a significant issue.

Several promising D4Ag solutions emerged in recent years that offer lessons to those entering the market.

The following include some of the multiple actors that are already present in the Sahel countries and deploying such solutions on a broad scale. SNV launched two Geodata for Agriculture and Water (G4AW) projects: Sustainable Technology Adapted for Mali's Pastoralists (STAMP) located in Mali and Mobile Data for Moving Herd Management (MODHEM) based in Burkina Faso. Espace Geomatique société anonyme à responsabilité limitée (SARL), Georisk Afric SARL, and Cargitech SARL have all introduced drone-based D4Ag efforts. Afrique Verte, Manobi, and Esoko provide market linkage and supply chain services. Akvo, Viamo and others act as data intermediaries and provide data intelligence. Below is an overview of D4Ag use cases identified through interviews and survey are presented for Burkina Faso and Mali as well as some examples for the different countries.



Rambaldi Giacomo, CTA

Burkina Faso has laid the D4Ag groundwork, not only through investments in connectivity but also through the development of middleware. D4Ag started emerging in the country about 15 years ago.⁴⁴⁰ More recently, e-Burkina, a World Bank-supported platform in Burkina Faso, helps digitalise land registrations and farm profile systems. This service provides farmers with more information about how much land they have, how they should use it, and how they can protect themselves against drought. Burkina Faso is also leading the way in the field of open data for agriculture, working on a coalition in the Sahel gathering various actors including the Ministry for the Development of Digital Economy, the Ministry of Agriculture, Global Open Data For Agriculture and Nutrition (GODAN), Akvo, and the Permanent Interstate Committee for Drought Control in the Sahel (CILSS). Drone technology is well represented in the Sahel countries with several companies offering services.

However, the benefits of D4Ag have yet to be fully realised because solution providers are still struggling to feed highly localised data into their IVR services. Although the solutions





Rambaldi Giacomo, CTA

require further refinement, the tactics used to scale can provide inspiration for others. For example, open platforms allow large farmer federations to contribute directly, rather than work through government authorities. This increases efficiency and participation.

In **Mali**, the initial successes of STAMP's Garbal services⁴⁴¹ exemplify the potential for carefully cultivated partnerships, programme flexibility, and commercially-focused programme design to address the needs of climate-vulnerable and conflict-affected pastoralists in the Sahel. This project provides Malian pastoralists with satellite-driven insights about the location of grazing grounds and water, crowdsourced information about grazing quality and availability, and locally relevant market price information. It is funded by the Dutch government through the G4AW (Geodata for Agriculture and Water) programme and implemented by a

consortium of Dutch NGO SNV, Orange Mali, Malian NGO TASSAGHT, and Satellite data processor Hoefsloot Spatial Solution.

In a second phase, Garbal will roll out financial access services (leveraging Orange's mobile money platform) and input access (in partnership with regional input providers). Working with these aggregators and value chain actors, the Garbal team believes it can build upon existing infrastructure, while also developing a long-term sustainable business model. As STAMP's Garbal demonstrates, models that achieve significant impacts while linking pastoralists and farmers to value chain actors to ensure commercial viability will underpin D4Ag's contributions in the Sahel.



In **Niger**, the “Tele-Irrigation” (from TECHINNOV) is a technological process that allows a farmer to remotely control the irrigation system of his farm and follow an intelligent distribution of water (needs, quantity, time, type of speculation), regardless of its geographical position and time, by means of his mobile phone and solar. Tele-Irrigation can also collect and disseminate real-time and remote meteorological and hydrological data including temperature, soil moisture content, rainfall, solar radiation and wind speed. This process allows the farmer (i) time and energy savings; (ii) increased irrigable area; (iii) increased production and income; and (iv) controlled water management.

In **Chad and Mauritania**, few companies are offering market linkage and advisory services in the agriculture sector and the number of D4Ag use cases identified through the survey and interviews is low.

Outlook

The success stories in the Sahel highlight that it is possible for D4Ag solutions to make an impact even in challenging conditions. Still, for D4Ag to truly take off, there needs to be much more political will for D4Ag across the region. It is strong political will that will set the stage for countries to make the requisite policy changes and enabling investments for D4Ag to take off.

Lessons



- ▶ To bring greater benefit to the agricultural value chain actors it is paramount to better understand their needs and the needs of smallholder farmers and to develop relevant/adapted/gender-sensitive services. Examples in the Sahel highlight that it is possible to serve even highly marginalised segments with success.
- ▶ It is not enough to focus on registration. Impact is only achieved when a service is utilised: important work should be done to increase service use.
- ▶ Data quality and accessibility must be improved to aid actors in making informed, evidence-based decisions. This need is particularly prescient given the context of climate change, in which experience no longer serves as a reliable barometer.
- ▶ Actors recognise that data intermediaries/aggregators⁴⁴² and data storage systems improve agricultural value chains. Different datasets should be brought together to increase value. Data sharing is paramount.
- ▶ Developing human capital at every level of the D4Ag ecosystem is crucial: All actors in the agricultural value chains (from smallholder farmers to extension officers and policy makers) must build digital skills and literacy in order for D4Ag to expand.
- ▶ Various kinds of business models are explored by agri-preneurs and, to create jobs for youth and women, their efforts require specific support, such as incentives for small-business and market development assistance.



ANNEX 2

STAKEHOLDER CONSULTATIONS

Name	Entity
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Amadou Ba	World Bank
Amare Mugoro	CommonSense project
Amsata Niang	ANIDA
Ananth Raj	Farm to Market Alliance
André Laperrière	Godan
Andrew Gartside	DFID
Andrew Nevin	Binkabi
Anelyia Muller	World Bank
Angelique Uwimana	FAO
Angus Keck	AgUnity
Anne Bastin Ndiaye	IFC
Arnaud de Vanssay	EU Delegation
Asaye Asnake	Farm Africa ET
Awa Caba	Sooretul
Ayodeji Balogun	AFEX
Ayokanmi Ayuba	Technoserve
Bekure Tamirat	Gebeya
Belinda Bwiza	OneAcreFund
Ben White	VC4Africa
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Bernhard Kowatsch	WFP
Bolaji Akinboro	Cellulant
Bolaji Akinboro	Cellulant
Brook Ashinne	Viamo

Name	Entity
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Clara Colina	MasterCard Foundation
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Daniel Asare-Kyei	Esoko
David Muwonge	NUCAFE
Diouf Mamadou Coumba	PRODAC
Eli Pollak	Apollo Agriculture
Elias Gossaye	Apposit
Elias Nure	Agricultural Transformation Agency
Elisa Minischetti	Yara International
Ethan Laub	MOSS ICT/M-BIRR
Farah Dib	World Bank
Filippo Brasesco	FAO
Florien Habinshuti	PSDAG (USAID)
Getamesay Demeke	Interaide
Girma	Meki Batu Union
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Harriet Blest	VIAMO
Heiner Bauman	PAD
Hillary Miller-Wise	Tulaa
Hussain Suleman	SigFox
Ifeanyi Anazodo	FarmCrowdy
Ikenna Nzewi	Releaf
Ilisa Gertner	Chemonics
Innocent Mudenge	NYAB
Jasper Spikker	Agriterra
Jean Louis Uwitonze	PSDAG (USAID)
Jeehye Kim	World Bank



Name	Entity
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Jonas Chianu	AfDB
Joshua Ayinbora	Groital Farms
Joshua Thompson	AAIN
Jovani Ntabgoba	N-frnds
Judy Payne	USAID
Justine Mucyo	Holland Greentech
Karin Lion	Digital Green
Karl Wurster	USAID
Katie Hauser	USAID
Kebede Ayele	Digital Green
Khalifababacar SARR	GIS Association
Laurent Cochet	Interaide
Levon Minassian	Arable Labs
Liisa Smits	Ignitia
Luda Bujoreanu	World Bank
Mamadou Sall	Bayseddo
Marc Schut	IITA
Marco Streng	Agriterra
Marise Blom	Scopelnsight
Masresha Taye	International Livestock Research Institute/Index Based Livestock Insurance
Melat Mebratu	MOSS ICT/M-BIRR
Mikael Hook	MasterCard Foundation
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Mutembei Karakui	GIZ
Natalia Pshenichnaya	GSMA mAgri
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Papa Samba Diop	APIX
Paul Wechuli	WaziHub
Peter Githinji	AAIN
Ranveer Chandra	Microsoft
Reha Yudarkal	IBM
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Robert Berlin	Syngenta Foundation
Ruud Grim	G4AW
Sandi Roberts	AgDevCco
Saskia Vossenbergh	FMO
Selina Kim	IBM
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Shirley Somuah	Cardinalstone Partners
Shreya Agarwal	Digital Green
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Stephane Devaux	EU Delegation
Stephen Ibaraki	REDD Capital
Stewart Collis	aWhere
Sylvie Nirere	IDH
Tiphaine Crenn	IFC
Tomaso Ceccarelli	CommonSense project
Van Jones	Hello Tractor
Venkat Maroju	SourceTrace
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ANNEX 3

DETAILED METHODOLOGY

In this report, the Dalberg team and CTA sought to analyse the state of D4Ag in Sub-Saharan Africa and to construct a current-state baseline as well as projections for key D4Ag sector characteristics and trends (historical and future-facing) on the basis of primary data collection, secondary research, and forecasting models.

This methodology provides an overview of the overall approach, the key tools used, and critical assumptions for a few select areas of analysis. Where not covered in this methodology, relevant information on assumptions and sources is embedded in the endnotes section of the report.

The data collected for this report is the intellectual property of CTA and Dalberg, but our hope is to make additional elements of the underlying data available in future publications and via the selective release of data sets for researchers. Additionally, the CTA and Dalberg teams – in collaboration with other sector knowledge leaders and funders and as part of our commitment to open agriculture data – are exploring opportunities to develop an open, digitalised, publicly available, and regularly updated version of the D4Ag solution database which will serve as a knowledge tool for the entire sector.

Advisory Council

An Advisory Council was convened enlisting experts from public and private sector actors, thought leaders, foundation representatives and leading implementers. The individuals are detailed in the Acknowledgments section of the report. The Council was invaluable in informing the development of the report, in particular around refining the strategic framework used to investigate D4Ag's role in Africa's agricultural transformation; reviewing, and providing feedback on the report's various drafts and insights; providing input on data sources and advising on how to tailor key report messages to its multi-sectoral audience.

Data collection

To gather the required information, we relied on **sector interviews**, a **large-scale survey of solution providers**, and **desk research**. These data collection activities fed into the development of a large **database of D4Ag solutions**, which was a core analytic tool for the effort and is meant to serve as a refreshable baseline data set for the sector for years to come.

D4Ag solutions database

The CTA-Dalberg D4Ag solutions database (the 'D4Ag database') currently contains information on **410+ active D4Ag solutions**, of which the **data set used for all analyses in this report focused on 390 active D4Ag solutions**. The others (typically very small or very early stage enterprises) were launched in recent months or were discovered during late stages of the report editorial process. We will include and analyse these additional solutions in the next edition of the report.

D4Ag solutions for the purposes of the database include both specialised D4Ag enterprises with a single D4Ag solution and individual D4Ag services/solutions developed and distributed by a third-party parent organisation such as an NGO, MNO, agribusiness, or technology company (both big and small). All of these solutions are either headquartered in Sub-Saharan Africa or focus a substantial portion of their activities on the region if they are incorporated or led from other geographies.

We estimate that the D4Ag database likely represents **90%+ of all existing and functioning D4Ag solutions in Africa**. While we attempted to make our database of solution providers as comprehensive as possible, it is not by any means exhaustive, owing to the time constraints facing the report's production team and the rapidly evolving nature of the D4Ag sector where new D4Ag solutions get launched almost weekly in Africa.

Beyond missing some of the newest start-ups, for several use case categories in this report, the boundaries between D4Ag solutions and out of scope enterprises were not always clear. For instance, in the financial access use case, traditional banks and MFIs are increasingly digitising their operations and incorporating digital features into their products and services even if such products are not explicitly branded as being 'digital'. In the macro agri-intelligence use case, a growing number of donor-funded initiatives and private sector solutions are exploring various uses of data for agriculture sector intelligence but have not yet fully productised such tools, or are exploring them within the context of a broader technology category (e.g., satellite imaging intelligence) and not limiting their activities to agriculture. It is almost certain that a number of such financial access and agri-intelligence solutions are not in the database.



In addition to 'live' solutions, the database tracks **>70 defunct solutions** which have ceased operations due to business model failure, the end of donor funding, or business model changes that have taken them out of the D4Ag sector (e.g., moving from D4Ag financing to an urban fintech focus). The data set of defunct solutions is far less comprehensive than that of the active players. Based on data from other early D4Ag solution databases in the sector, most notably GSMA's mAgri tracker (active until ~2014), we estimate that there are at the very least 50 and possibly as many as 100 other defunct D4Ag solutions that are currently non-operational but were in business at some point over the past 15 years.

To generate the list of **>480 total solutions** in the database (**460 analysed specifically in this report**), the Dalberg and CTA teams drew on a wide range of sources including old data (2013-2014) from the no longer functioning GSMA mAgri tracker, CTA's ICT4Ag solution database, Dalberg's ICTAg database (developed in support of the Bill and Melinda Gates Foundation's ICT4Ag strategy in 2016), Dalberg digital agriculture landscaping studies for select African countries (developed jointly with MercyCorp's AgriFin Accelerate team), the Global Open Data for Agriculture Network (GODAN) membership list of >920 member organisations, MasterCard Foundation Rural Finance Learning Lab's data sets on digital agricultural finance providers and intermediaries, and Africa AgTech startup landscape maps from organisations like Disrupt Africa and Briter Bridges. Less systematically, we supplemented this data with additional D4Ag solutions surfaced through desk research on specific use cases, expert interviews, and country case study field trips.

The database tracks ~20 data fields for each solution that cover factors such as geographic location and focus, year of launch, organisational type/sub-type, use case type (all use cases covered, primary use case, primary use case sub-type), reach (registrations, engaged/active users), revenues, profitability, inclusion (e.g., gender and youth disaggregated data), impact (i.e., yield and income), and contact information. For factors like reach, revenue, and impact only a subset of all solutions have data.

Alongside this central database we collected a few other datasets used for the analyses including (i) a tracker of D4Ag transactions (based on press releases, PE/VC specialist reports on Africa, and our expert interviews); (ii) a small database on D4Ag donor funding based on desk research and funder interviews; (iii) a D4Ag impact tracker capturing yield, income, and other impacts of D4Ag solutions (based on the USAID ICT4Ag impact tracker and extended with data points found through desk research and interviews).

Expert interviews

Between October 2018 and February 2019, the Dalberg team conducted ~120 semi-structured interviews of leading experts and D4Ag solution leaders in the fields of agriculture technology and digital services, agriculture and food markets, donor initiatives, and government programmes. In many cases, CTA provided connections to interviewees, while in other cases the Dalberg team sourced contacts through its global network of consulting professionals or through external connections. Interviews generally ranged from 30 to 60 minutes. Where possible, the team corroborated the interviewees' statements with secondary data acquired through desk research.

The interview insights then fed into a variety of the analyses for this report including the D4Ag database, country case studies, use case segmentation, business model analyses, and general perspectives on sector trends.

D4Ag solution survey

Drawing on an early version of the D4Ag solution database, CTA and Dalberg collaborated to design the D4Ag solution survey during the autumn of 2018. The survey launched in mid-November 2018 and remained open for data collection until the first week of February 2019.

Dalberg distributed the survey to all solutions and enterprises it had identified up to that point (430) via extensive desk research prior to the survey's design, which included all CTA-supported or affiliated solutions.

Dalberg sent several follow-up emails, collecting 175 responses by February 2019. Of these 175 responses, 35 were highly incomplete or otherwise flawed. Once these were removed, Dalberg proceeded to analyse the final 'clean' dataset of 140 survey responses (~32% response rate). Dalberg then supplemented analysis of these data points with extensive secondary data collection.

Desk research

We supplemented our primary research with analyses of publicly available knowledge resources published by international development organisations such as CTA, USAID, GSMA, World Bank, FAO, CGAP, AGRA, GIZ, and the MasterCard Foundation. In addition, we conducted searches of academic literature through academic research databases, consulted the official reports of solution providers where available, and reviewed relevant news coverage. In sum our team reviewed hundreds of sources, ~250 of which are captured in the report's Bibliography.



Country case study field work

Between November 2018 and March 2019, the Dalberg team conducted five in-person country case study field visits and two 'light touch' case studies via phone interviews or brief in-person conversations. Fieldwork in Ethiopia, Rwanda, Nigeria, and Senegal leveraged the local knowledge of Dalberg's consulting professionals based in-country, while fieldwork in Ghana engaged local resources with strong knowledge of the local context. The team conducted in-person interviews in these countries and conducted supplementary interviews with local experts by phone.

The case studies of Kenya and the Sahel region relied on remote conversations with experts with D4Ag experience in these regions. Additionally, for Kenya, our team drew on interviews and data collected during the World Bank's Disruptive Agricultural Technology Challenge and Conference in Nairobi in March 2019.

Data analysis

The report looked at a large number of issues related to the D4Ag sector and relied on both qualitative and quantitative data.

Among other variables, quantitative data analytics focused on key elements such as:

- **Solution landscape:** The number, segmentation, and dynamics over time of D4Ag solutions
- **Reach and use:** The reach of D4Ag solutions – including different definitions of reach, 'engagement', and 'active' use; as well as the segmentation of the number of registered farmers, the most accessible reach variable, along dimensions such as use concentration, case, geography, and organisation type
- **Penetration analysis:** Assessment of D4Ag penetration in Africa along different definitions of the addressable smallholder farmer market
- **Revenues:** Sizing of current earned revenues of the D4Ag sector, split by organisation type and solution use case, as well as self-reported data on revenue sources
- **Addressable market:** Sizing of the addressable market (both in terms of the number of client and potential revenue pools)
- **Profitability:** Estimates of the share of the sector that are break-even/profitable based on self-reported data, triangulated across a number of survey questions for survey respondents
- **Inclusion:** Inclusivity of D4Ag solutions with a particular emphasis on the share of users who are women and youth (<35 years)
- **Impact:** Self-reported impact data (particularly

yield and income) for solutions in our database and the broader academic literature on D4Ag impacts based on peer reviewed publications, publicly available publications, and proprietary M&E materials shared by a few large players

- **Investments:** Analyses of volumes, number of transactions, and investment instruments for PE/VC transactions focused on African D4Ag start-ups and non-African D4Ag start-ups that have an exclusive or major focus on Africa
- **Donor funding:** Analyses of the volume, composition, and trends over time of the development sector (DFI, bilateral, private foundation) funding for D4Ag

The methodology and key assumptions for all of these analyses are discussed in the endnotes throughout the report, tied to the relevant report sections. Below we delve into a few of the more critical analyses and assumptions.

Solution landscaping and segmentation

Our team categorised all solutions captured in the D4Ag database into five broad categories of use cases (advisory services, market linkages, financial access, supply chain management, and macro agri-intelligence). In addition, we collected information on D4Ag infrastructure players – typically referred to as D4Ag or agriculture data 'intermediaries' in the report. These are essentially D4Ag data, software, and analytics vendors who work across multiple use cases on a B2B (and occasionally B2C basis) but are not aligned to any individual farmer facing use case.

The categorisation of solutions relied on self-reported responses for survey participants and then expert-based judgments by the Dalberg team for other organisations in the database.

Reach and inclusion – registered, engaged/active, women and youth users

Our team collected total reach information in terms of the number of farmers registered or self-reported 'active' users on the basis of the survey, interviews, and desk research. For the largest players in the database, every attempt was made to validate the numbers by interviewing representatives of the organisation or by talking to their peers and sector experts. Active women user information was based on the solution provider responses to the survey supplemented with interviews and desk research.

Definitions of 'active' or 'engaged' users lack standardisation or consistency across use cases and they are not transparent or comparable; an 'active' financial user might have money in a savings account while an 'active' market linkages user might report prices each day. Surveyed solutions reported both self-defined 'active users' and 'users active at least once a month'; the self-defined figure was less than



the monthly figure, suggesting that solutions define 'active' reasonably, but still subject to tremendous methodological and terminological ambiguity and variation.

As noted in the body of the report, to deal with these inconsistencies, we have created a new definition of 'engaged' users as a catch-all category to differentiate farmers who use D4Ag solutions, to at least some extent, from those who are registered but are in reality non-users.

Estimated revenues

We calculated revenues by (1) establishing average annual revenue per user (ARPU) from solution providers that publish both user and revenue information or shared such information with us via interviews and the survey; (2) we mapped ARPU from (1) for solution providers that publish numbers of users but not revenues to estimate their total revenue; (3) for solution providers that publish neither number of users nor revenues, we used an averaged number of users from (1) and (2) and average ARPU from (1). Adding the three analyses together produces a minimum, maximum, and average estimate of total D4Ag revenues.

Extrapolation across organisations with unknown revenues was done for commercial enterprises, NGOs, and MNOs, as revenues flowing to other organisation types are difficult to isolate and quantify.

D4Ag market penetration and total addressable market analyses

This analysis was based on two key inputs: (i) ARPUs across each use-case – retrieved from estimated revenue figures; (ii) the expected total number of farmers in Africa that could theoretically receive a D4Ag product or service.

The total number of addressable farmers, in itself, is a figure on which there is no clear consensus in the sector (or the broader agriculture development literature on Africa).

For the purposes of this report we estimate a total of 63 million smallholder (<2 hectare) farms in Africa based on the latest estimates from a systemic review of global smallholder farmer estimates.⁴⁴³ The number is derived by multiplying what we believe is the most recent and credible estimate of the number of Sub-Saharan African farms (77 million) by the share of those farms that are under two hectares in size (82%). Using an average of three adults per smallholder farm from the literature, we estimate that the total number of smallholder farmers in Sub-Saharan Africa is 190 million. The figure below shows these numbers and the underlying sources. We use the top of the range for our estimate as that reflects more recent and granular data sets.

See Figure 38: Smallholder farmer estimate

In addition to the number of smallholder farmers, we also estimate the number of pastoralists in Africa, small agriculturalists engage in livestock production who *do not* have land and therefore cannot be estimated from smallholder farm data. There are a range of estimates for the number of African pastoralists in the literature (25-80 million), complicated by the paucity of data and definitional challenges (e.g., distinction between pastoralists and agro-pastoralists). We believe the most reliable data, with granular country level estimates, comes from a UNECA study in 2015, which we have supplemented with research on additional countries (e.g., Tanzania) that have pastoralists but were not included in the data set to estimate a total of 60 million pastoralists in 2018. See Figure 39.

Figure 38 **Smallholder farmer estimate**

Statistic	Figure	Source	Year	Underlying source years
Farms in Africa	51M	<u>Lowder, et al.</u>	2016	1960-2008
	77M	<u>Lowder, et al.</u>	2016	1970-2014
Share of African smallholder farms <2ha	82%	FAO	<u>2001, 2013</u>	1990; 1996-2005
Smallholder farms in Africa <2ha	42–63M	Calculated	-	-
Number of adults (14-60) per African smallholder farm	~3	<u>Deininger, et al.</u>	2017	2010-2012
Number of adults (14-60) on smallholder farms <2ha	125–189M	Calculated	-	-



Using a pastoralist household size of six based on country survey data, we estimate a grand total of 8-10 million pastoralist households in the region.

Combining across farm-based smallholder farmers and pastoralists, and using the top of the range based on our interpretation of the numbers, we estimate a grand total of 250 million smallholders and 72 million smallholder/pastoralist households in the region.

To estimate household penetration of D4Ag solutions, we looked at the estimated number of registered farmers for each use case in comparison to the total number of smallholders and smallholder households in Sub-Saharan Africa.

See Figure 40 below with D4Ag registered user penetration of the market, overall and by use case.

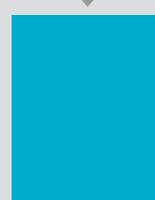
Figure 39 African pastoralist estimates⁴⁴⁴

Statistic	Figure	Source	Year	Underlying source years
Pastoralists	25M	Bonfiglioli	1992	
	40M	Cervigni, et al.	2016	
Pastoralists (Sahel and Horn)	58M	UNECA	2015	
Agro-pastoralists (incl. some smallholder farmers)	80M	Cervigni, et al.	2016	
	50-200M	Bayer & Bayer	2015	
Number of pastoralists	50-60M	Dalberg estimate using existing ranges	–	–
Number of adult equivalents per African pastoralist households	6	ElHadi, et al.	2012	2012
Number of pastoralist households	~8-10M	Dalberg estimate using existing ranges	–	–

Figure 40 D4Ag registered user penetration of the market, overall and by use case

EOY 2018

Assumes per SHF
(190M SHFs plus
60M pastoralists)



Upper bound

Assumes per SHF
household
(63M SHF
HH plus 10M
pastoralist HHs)



Lower bound

Total reach	33.1M	13%	45%
Advisory services	22.6M	9%	31%
Financial access	5.6M	2%	8%
Market linkages	2.5M	1%	3%
Supply chain	2.4M	1%	3%



The analysis in the preceding figures shows that, taken as a share of all smallholders and momentarily assuming *no* duplications between farmers registered for different categories of D4Ag solutions, the total reach (33.1 million) represents 13% of all smallholders (250 million). With a duplication assumption of 20% (as explained in the body of the report), the estimated reach figure of ~26 million farmers represents an overall penetration of smallholders of ~10%. We believe that the actual penetration very likely sits in this 10-13% range today.

Viewed from the perspective of smallholder households, the penetration figure could be a lot higher. If one assumes, for instance, that households only subscribe to one solution, penetration could be as high as 45% in 2018, but we view this assumption as being highly improbable based on observed behaviour in the field, particularly for advisory solutions which can easily have many subscribers or subscriptions per each smallholder farmer household. Because data on the average number of solutions per household is unavailable today from smallholder surveys, we anchor the discussion in the report on the overall number of smallholder farmers rather than the number of households for the penetration estimate (i.e., we propose the 10-13% penetration figure).

The total addressable market analysis (covered in depth in the body of the report and related endnotes in Chapter 3) draws on this same data for overall population sizing and then multiplies it by estimated ARPU ranges for each solution. As one nuance in that analysis, we assume that the addressable market (in terms of revenues) for advisory solutions is bounded by the number of all smallholders whereas for use cases like market linkage and financial access, the more relevant metric is the number of households as the solution (e.g., credit, insurance contract, digitally-enabled market off-take arrangement) is tied to the farm rather than to the number of individuals on that farm. To derive the final addressable market figures, the resulting potential revenue pools are adjusted based on the connectivity constraint for the market (e.g., share of households with mobile subscriptions or share that have access to phones).

While our survey and interviews only focused on smallholder farmers as users of the digital solutions, we also believe that there are other users within the agricultural ecosystem such as traders, extension workers, researchers, policy makers but are not specifically referenced in this report.

Future reach and revenues

The future growth rate is based on self-reported historic growth rate and expected growth rate from survey respondents. We did not make any projections regarding the growth rate of the number

of solutions, as that depends on how fast the market consolidates. In this analysis, it is assumed that 20% of users are double-counted in 2019 and 2022 and the same number in 2030 (a simplifying assumption which is unlikely since duplication in use will grow as more farmers register for services). Further, based on survey data, ~42% of all unique users are 'engaged'.

Survey participants reported a historical (three year) annual growth rate of 44% in terms of their number of registered farmers, a figure also triangulated with a few large D4Ag actors who were not survey respondents. From a forward-looking perspective, survey participants projected an average growth rate of 55% over the next three years in their client base. We also looked at the absolute number of new farmers that were registered over the past three years to derive a more conservative scenario in which farmer acquisition by D4Ag enterprises does not accelerate but instead proceeds with the same pace in terms of the absolute number of farmers registered each year.

The three scenarios (55% CAGR for aggressive growth, 44% CAGR based on historical growth, and 22% CAGR, derived, for conservative growth), then yielded our estimates of 60/100/125 million farmers registered by 2020 from a 33 million farmer base. We dismissed the top end of this projection as being too aggressive and the report then used the 60-100 million registered farmer range in 2022 to also derive the market size based on unique and engaged farmers.

Estimated investments and donor funding

We calculated investments based on desk research data (supplemented with interviews) of relevant yearly PE/VC investments to D4Ag enterprises operating in Africa. We triangulated the resulting estimates with data reported by organisations like AgFunder as well as players like Disrupt Africa who track start-up investments in the region on an annual basis by theme and sector (in this case, AgTech).

For donor funding volumes, building on earlier analyses of donor trends in the space developed by Dalberg, we sourced estimates of donor funding from ~15 known active funders in the sector. In some cases the number was a directional estimate derived from interviews, in others (e.g., EU, BMGF) our team had access to underlying project databases which were generously shared by some of the Advisory Council members for the purposes of this report.



ENDNOTES

Executive summary

- 1 Food and Agriculture Organization of the United Nations (FAO). 2017. 'The future of food and agriculture: Trends and challenges' (www.fao.org/3/a-i6583e.pdf).
- 2 The baseline number of smallholders in Sub-Saharan Africa used in this report is estimated at 73 million agricultural households, including smallholder farm and pastoralist households, and a total of 250 million smallholder farmers and pastoralists (i.e., adults engaged in these agricultural activities). For details on sources for this estimate, please see the Methodology section in the Annex.
- 3 For details on how this – and all other figures in the executive summary – have been calculated, please refer to the main body of the report as well as the Annex, where we present a detailed Methodology.

Chapter 1

- 4 FAO. 2017. 'The future of food and agriculture: Trends and challenges' (www.fao.org/3/a-i6583e.pdf).
- 5 van Ittersum, M.K. *et al.* 2018. 'Can sub-Saharan Africa feed itself?' PNAS (www.pnas.org/content/pnas/113/52/14964.full.pdf).
- 6 FAO. 2017. 'The future of food and agriculture: Trends and challenges' (www.fao.org/3/a-i6583e.pdf).
- 7 These factors bring a number of other risks, such as poor educational outcomes and susceptibility to communicable and non-communicable diseases. See FAO. 2017. 'Regional Overview of Food Security and Nutrition' (www.fao.org/3/a-i7967e.pdf).
- 8 FAO and UN explain, "Nutrition security differs from food security in that it also considers the aspects of adequate caring practices, health and hygiene in addition to dietary adequacy." See FAO. 2018. 'The State of Food Security and Nutrition in the World' (www.fao.org/3/I9553EN/i9553en.pdf). We believe that agricultural transformation has the potential to most directly contribute to dietary adequacy.
- 9 Ibid. See also FAO. 2018. 'Africa Regional Overview of Food Security and Nutrition: Addressing the Threat From Climate Variability' (<https://reliefweb.int/sites/reliefweb.int/files/resources/ca2710en.pdf>); Wiebe, K. *et al.* 2016. 'The Effects of Climate Change on Agriculture and Food Security in Africa'. International Food Policy Research Institute (IFPRI), book chapter (www.ifpri.org/publication/effects-climate-change-agriculture-and-food-security-africa).
- 10 Goedde, L. *et al.* 2019. 'Winning in Africa's Agricultural market'. McKinsey and Company (www.mckinsey.com/industries/agriculture/our-insights/winning-in-africas-agricultural-market).
- 11 McArthur, J. and McCord, G.C. 2014. 'Fertilising Growth: Agricultural Inputs and Their Effects in Economic Development'. The Brookings Institution (www.brookings.edu/wp-content/uploads/2014/09/fertilizing-growth-final-v3.pdf).
- 12 High-end estimates suggest that women constitute 60–80% of African smallholder farmers. More recent research suggests that female share of crop production in Africa is closer to 40-50%, but women are likely overrepresented in the most marginal and informal subsistence agriculture value chains in the continent. See Doss. 2018. 'Women and Agricultural Productivity: Reframing the Issues'. *Development Policy Review* (www.onlinelibrary.wiley.com/doi/epdf/10.1111/dpr.12243).
- 13 MasterCard Foundation. 2018. 'Young Africa Works'.
- 14 FAO. 2014. 'Contribution to the 2014 United Nations Economic and Social Council (ECOSOC) Integration Segment' (www.un.org/en/ecosoc/integration/pdf/foodandagricultureorganisation.pdf).
- 15 Twenty out of 47 reporting African Union countries were on track for their 2025 CAADP/Malabo Declaration commitments by the end of 2017, according to the Africa Agriculture Transformation Scorecard. See 2017 scorecard data in Alliance for a Green Revolution in Africa (AGRA). 2018. 'Africa Agriculture Status Report' (www.agra.org/wp-content/uploads/2018/10/AASR-2018.pdf).
- 16 African Development Bank (AfDB). 2016. 'Feed Africa: A Strategy for Agricultural Transformation in Africa 2016-2025' (www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Feed_Africa_Strategy_for_Agricultural_Transformation_in_Africa_2016-2025.pdf).
- 17 See, e.g., African Centre for Economic Transformation (ACET). 2017. 'African Agricultural Transformation Report' (www.acetforafrica.org/acet/wp-content/uploads/publications/2017/10/ATR17-full-report.pdf); Alliance for a Green Revolution in Africa (AGRA). 2018. 'Africa Agriculture Status Report' (www.agra.org/wp-content/uploads/2018/10/AASR-2018.pdf).

Chapter 2

- 18 It is important to clearly define not only what the D4Ag sector is, but also what it is not. One such critical distinction important for the scope of this report is to separate D4Ag solutions from the much broader category of agriculture technology (AgTech), which includes many important technologies that are either not digital (e.g., basic farm machinery and tools) or where digital elements play a secondary role to other innovations (e.g., farm robotics and automation, biotech and biochemistry, innovative food and farming systems such as indoor "vertical" farms, off-grid energy solutions for agriculture that lack digital business model components, etc.). For a helpful visualisation of digital agriculture vs. AgTech, see USAID Feed the Future. 2018. 'Policy Brief #5: ICT Solutions for Inclusive Agricultural Value Chains', available at (https://www.agrilinks.org/sites/default/files/brief_5_-_ict_solutions_for_agricultural_value_chains.pdf).



- 19 For instance, digital advisory services are sometimes categorised as digital farmer information or digital extension services (e.g., GIZ, USAID), farm management software is sometimes separated out into its own use case area as distinct from digital advisory services (e.g., BMGF, AgFunder), digital market linkages to inputs and market linkages to off-take markets are sometimes split out into separate use case areas (e.g., World Bank), digital tools for data collection and M&E are sometimes seen as a separate end-use case (e.g., GIZ) rather than as underlying data collection and data analytics tools that support other use cases. For alternative D4Ag frameworks reviewed as source materials for this report see, e.g., USAID Feed the Future. 2018. 'Policy Brief #5: ICT Solutions for Inclusive Agricultural Value Chains' (https://www.agrilinks.org/sites/default/files/brief_5_-_ict_solutions_for_agricultural_value_chains.pdf); GIZ. 2017. 'Use of ICT for Agriculture in GIZ Projects'; World Bank. 2017. 'ICT in Agriculture e-Sourcebook'; Bill and Melinda Gates Foundation. 2017. BMGF ICT4Ag Strategy; World Bank. 2019. 'Africa Smallholder Agriculture Digital Disruption Conference Proceedings' (full report forthcoming); USAID. 2018. 'Digital Tools In Agricultural Programming'; FAO. 2013. 'ICT Uses for Inclusive Agricultural Value Chains'. See also AgTech investment and innovation ecosystem maps from AgFunder (www.agfunder.com) and BriterBridges (www.briterbridges.com).
- 20 USAID. 2018. 'Data Driven Agriculture: The Future of Smallholder Farmer Data Management' (<https://www.usaid.gov/digitalag/documents/data-driven-agriculture>).
- 21 See, e.g., GFAR, GODAN, CTA. 2018. 'Digital and Data-Driven Agriculture: Harnessing the Power of Data for Smallholders', available at <https://f1000research.com/documents/7-525>; USAID. 2018. 'Data Driven Agriculture: The Future of Smallholder Farmer Data Management' (<https://www.usaid.gov/digitalag/documents/data-driven-agriculture>).
- 22 See GSMA's case study of the earlier version of Esoko's business model, available at https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2016/02/Case_Study_-_Esoko.pdf; currently the Esoko model has evolved substantially with several products including a farmer information services solution (with ~1 million registered farmers), a data collection tool (Insyt), and – the organisation's current primary focus – a market linkage platform solution called the Digital Farmer Service (DFS) (see <https://esoko.com/>).
- 23 See an overview and assessment of the CKW program in Van Campenhout (2016), available at <https://www.tandfonline.com/doi/full/10.1080/1369118X.2016.1200644>.
- 24 For an overview of several such early-stage MNO mAgri solutions see the GSMA mAgri case studies, available at <https://www.gsma.com/mobilefordevelopment/resources/mfarmer-case-studies/>.
- 25 The 80-28 Farmer Hotline is an SMS/IVR-based farmer information system with roughly 4 million registered farmers today, making it the single largest D4Ag solution in Africa. For more information, see <http://www.ata.gov.et/programs/highlighted-deliverables/8028-farmer-hotline/>.
- 26 The Zambia Integrated Agricultural Management Information System (ZIAMIS), which was launched in 2017 and has 1.5 million registered farmers in the country, was initially a platform for real-time management of payments and monitoring of agricultural transactions but is increasingly being used as a mass SMS service for smallholders.
- 27 Since 2017, Kenya's Agriculture and Livestock Research Organisation (KALRO) has launched 17 D4Ag applications which offer step by step information to manage chickens, crops like avocado, banana, garlic, and cassava, or how to diagnose and manage specific plant diseases and pests (e.g., army worm, maize lethal necrosis). See <https://www.scidev.net/sub-saharan-africa/agriculture/news/kenya-mobile-apps-transform-agriculture.html>.
- 28 The Smart Nkunganire System (SNS) was developed in 2018 by BK Techouse, a sister company to Bank of Kigali. In partnership with the government of Rwanda, by mid-2019, over 1.4 million farmers and all agro-dealers in the country have been registered and validated within SNS and actively use it to receive advisory messages and market information. See <https://ktpress.rw/2019/05/bank-of-kigali-launches-ikofito-boost-agriculture-financing/>.
- 29 See Figure 18 in Chapter 3 for a more in-depth discussion of MNO D4Ag business models in general and Viamo and Orange in particular.
- 30 iShamba is an SMS and call centre-based farmer information service in Kenya that provides smallholder farmers agricultural advice, crop management best practices, weather updates, and market price information. Started in 2015, the solution has ~350,000 registered farmer clients. See <https://ishamba.com/>.
- 31 iCow is a mobile phone agriculture advisory platform, which utilises push SMS services and a call centre to offer farmers advice on dairy, poultry, and soil management practices. Started in 2012, iCow currently has over 820,000 registered farmers.
- 32 While Verdant includes SMS-based farmer information advisory service in Nigeria (see <https://verdant.ng>), the solution is much broader in nature with market linkage and macro agri-business intelligence elements.
- 33 FarmerLine, launched in 2013 and currently reaching ~200,000 registered farmers, has a number of D4Ag services in its portfolio; the 399 Farmer Information Service, which is an extension of Farmerline's original business model, provides smallholder farmers weather forecasts, market prices, and information about cultivation methods and quality farm inputs via SMS and voice message in nine West African languages. See <https://farmerline.co/>.
- 34 The Regional Agricultural Trade Information Network (RATIN), a service of the Eastern Africa Grain Council provides SMS-based market price and volume information to smallholders at large scale; ~400,000 are farmers registered for the service in 2018 in Kenya, Uganda, Tanzania, Burundi, and Rwanda. See www.ratin.net.
- 35 Since 2011 ECX features an SMS/IVR market data dissemination service (see <http://www.ecx.com.et/?AspxAutoDetectCookieSupport=1>); the ECX itself is a commodity exchange, with increasingly digitalisation of trading features (e.g., e-auction functionality), so this example only highlights the SMS market info service.
- 36 For some attempts in the literature to define precision agriculture and emerging precision advisory services for smallholders see World Bank. 2019. "Future of Food: Harnessing Digital Technologies to Improve Food System Outcomes"; USAID. 2018. "Digital Farmer Profiles: Re-Imagining Smallholder Agriculture".
- 37 See <http://www.climark.org/>.
- 38 Ignitia is a Swedish social enterprise currently focused on West Africa (Mali, Côte d'Ivoire, and Ghana) whose product is a 48 hour weather forecast, including monthly and seasonal predictions, delivered daily via SMS to smallholder farmers phones in partnership with African MNOs (<http://www.ignitia.se/isika>).
- 39 See further details in <https://www.apcam.org/index.php/documents/rapports-divers/165-les-lecons-appripes-du-projet-ewea-fis-au-mali-cercles-de-kolokani-et-de-diema/file>
- 40 Weather Impact is a Dutch enterprise founded in 2014 which focuses on innovative solutions to manage the risks of extreme weather and climate change. The company has four weather-based solutions for Africa smallholder farmers deployed jointly



with partners, Rain4Africa in South Africa, CropMon in Kenya, AgriCoach in Burundi, and CommonSense in Ethiopia, which combine weather, satellite, and – in some cases – soil data to deliver customised SMS-based advisory and early warning weather services to farmers. See <https://weatherimpact.com/about-us/>.

- 41 See the proceedings of the 2018 Fall Armyworm Tech Prize challenge (<https://fallarmywormtech.challenges.org>).
- 42 Plantwise, launched in 2012, is a global donor-funded network of health plant clinics and plant doctor agents that advise farmers on how to diagnose and treat pests and diseases; Plantwise has been digitalising its model with an online Plantwise Knowledge Bank, a number of D4Ag solutions for plant doctors, and is also experimenting via partners (e.g., Plantix) on delivering pest and disease management directly to farmers' phones (www.plantwise.org).
- 43 Waterwatch Cooperative is an NGO which is scaling an AI-enabled pest and disease surveillance and advisory system in East Africa, reaching 500,000 registered farmers in 2019 (see <https://waterwatchcooperative.com>).
- 44 WeatherSafe is a UK enterprise that is scaling a pest and disease and weather risk management advisory product for coffee farmers in Rwanda and Tanzania (see <http://weathersafe.co.uk>).
- 45 Agripredict is an AI-aided pest and weather risk management solution in Zambia (<http://www.agripredict.com/>).
- 46 Sat4Farming, launched in 2017, is a Netherlands G4AW (Geodata for Agriculture and Water) funded consortium of Touton (Mars' cocoa trader), Satelligence, and Grameen, to deliver customised advice and individualised seven-year Farm Development Plans to small-scale cocoa producers with the help of satellite imagery. See <https://utz.org/corporate-news/ghanaian-farmers-benefit-new-sat4farming-program/>.
- 47 ACCORD is a donor-funded pilot that has been specifically developed to help smallholder coffee farmers in Africa improve crop quality and yield by combining Earth-i's very high-resolution satellite imagery with WeatherSafe's data platform, to provide extensive crop, weather and pest analysis, and share the information via a mobile app. See <https://earth.space/accord/> <https://earth.space/accord/>.
- 48 Orange Garbal, a service privately operated by telecom company Orange Mali in partnership with SNV and with funding support from the Netherland Space Office (NSO), was established in 2017 and aims to improve the resilience of pastoralists to climate change through the access and use of geo-satellite data (see <http://www.snv.org/update/garbal-information-service-increases-pastoralists-resilience-mali>).
- 49 Started in 2017 by Agrics, Geodatics is a precision advisory service that integrates satellite imaging and farmer data to deliver geospatially tailored advice (see <http://geodatics.net/>).
- 50 Market-led User-owned ICT4Ag-enabled Information Service (MUIIS), launched in 2015, is one of the Dutch Ministry of Foreign Affairs initiatives called G4AW (Geodata for Agriculture and Water) implemented by CTA and now transitioned into a sustainable business – <https://muis.com/>.
- 51 CropIn, which has roughly 2 million farmer clients globally of whom the majority are in India but several hundred thousand are also in Africa, targets agribusiness clients but one of the main sources of value that CropIn delivers to its clients are remote-sensing based advisory services for smallholders (see <https://www.cropin.com/>). SatSure likewise relies primarily on satellite data for its farmer focused advisory services, financial risk assessment tools, and macro intelligence offering (see <https://www.satsure.co/>).
- 52 PAD, launched in 2015, works in Kenya, Ethiopia, and Rwanda and has significant scale, with 650,000 smallholder farmers across these three countries registered for PAD applications and services in 2018 (see <https://precisionag.org>).
- 53 CTA and Dalberg are tracking ~30 drone agriculture solution providers in the region, with headquarters in 13 African countries and operations and/or discrete projects in several dozen more. While these drone enterprises offer a variety of solutions for smallholder agriculture, the majority have an advisory component or are working with digital advisory partners. For more information on examples mentioned here, see AgrInfo/Jembe (<http://www.agrinfo.co.tz/>), Zionate Geospatial/AirborneAgric (<https://airborneagriconsolutions.com/>), ThirdEye (<http://www.thirdyewater.com/>), Astral Aerial (<http://astral-aerial.com/agriculture/>), AcquahMeyer Drone Tech (<https://amdronetech.com/>), Charis (<http://charisuas.com/#home>), and WeFly Agri (<https://www.weflyagri.com/en/>).
- 54 Yara's ImageIt is a farming application designed to measure nitrogen uptake in a crop (e.g., oilseed, wheat, and barley) and to generate a nitrogen recommendation based on the resulting photo using machine learning (see <https://www.yara.us/crop-nutrition/tools-and-services/imageit/>).
- 55 For more details on the application, developed jointly by PlantVillage and IITA, see <https://plantvillage.psu.edu/>.
- 56 For more details on Yiri Drotro, see <http://grainotheque.ci/>.
- 57 Plantix, a mobile advisory application for farmers and extension workers, developed by PEAT, a Berlin-based D4Ag startup in 2015 is an image-based diagnostic tool for plant diseases and nutrient deficiencies that is able to detect more than 240 plant pests and diseases automatically. It is used by over 700,000 smallholder farmers monthly, 80% of them in India. While Sub-Saharan Africa has not been a focus to date, Plantix has already expanded to North Africa last year and Sub-Saharan Africa expansion is part of the enterprise's strategy. Other solutions utilising a similar image processing and machine learning approach are likewise on the way with funding from donors like BMGF.
- 58 See <https://cropnuts.com/portfolio-item/smallscale-farmers/>.
- 59 AgroCares, launched in 2013, currently focuses on 7 African countries, expanding to 11 in 2019 for precision advisory and diagnostics services (see <https://www.agrocares.com>).
- 60 PlantVillage (see note 55) is currently experimenting with using the Cromptix sensor in Africa for integration with PlantVillage's diagnostic application (see <https://plantvillage.psu.edu/solutions>).
- 61 Yield Sky is designed for smallholder farmers to mount on a stick and walk around the farm to generate a detailed farm health scan via a Normalised Difference Vegetation Index (NDVI) that shows stressed crops, pests, diseases, and nutrient deficiencies. See <https://www.zenvus.com/products/yield/>.
- 62 UjuziKilimo, launched in 2015, uses sensor technology to measure soil characteristics, relay the information in real time to an analysis centre comprising a comprehensive database; and relay the information with the crop breed, fertiliser required, pest control, markets and other farm management tools to the farmer, in real time, through his/her mobile phone. See <https://www.ujuzikilimo.com/>.
- 63 Lentera is a Kenyan agriculture technology start-up (2016), which combines field sensors and satellite imaging to delivery precision agriculture advisory services to smallholders over their phones (<https://lenterafrica.com/>).



- 64 SunCulture's (<http://sunculture.com/>) soil sensors that are deployed alongside the company's off-grid solar irrigation pumps and feed into the enterprise's digital advisory platform.
- 65 Zenvus Smartfarm is an intelligent electronics sensor which when inserted in a farm soil collects pertinent data like humidity, temperature, pH, moisture, nutrients etc. and wirelessly transmits the data to a cloud server where advanced computational models translate this data into advisory recommendations via the Zenvus application. See <https://www.zenvus.com/products/smartfarm/>.
- 66 See <https://www.ibm.com/case-studies/t869341z93257n45>.
- 67 See <https://microsoftcaregh.com/2019/05/08/ai-edge-iot-agriculture-microsoft-farmbeats-farmers-kenya/>.
- 68 See https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/E-agriculture-Solutions-Forum-2018/TCS%20Digital%20Farming%20Initiatives_Shankar%20Tagad_ESF%202018_v0.2.pdf.
- 69 See <http://kitovu.com.ng/>.
- 70 For a profile of iShamba see note 30. For ATA's 80-28 Hotline see note 25. Mlimi Hotline is a multi-modal farmer call centre established by Farm Radio Trust in 2016 in Malawi to provide affordable, actionable and timely on-demand advisory services to farmers. The approach uses inbound and outbound calls combined with IVR, SMS services, and internet messaging, working in sync with participatory radio to raise awareness and encourage farmers to use the service. See <https://www.facebook.com/FarmRadioMw/posts/mlimi-hotline-is-a-multi-modal-farmer-call-centre-established-to-provide-afford/1562864670478907/>.
- 71 We estimate that at least 20% and likely as many as 30-35% of D4Ag advisory solutions in Africa today have some IVR functionality which reach over 10 million smallholder farmers registered for associated D4Ag solutions. For an overview of how IVR solutions function in the agriculture space, see https://www.agrilinks.org/sites/default/files/resource/files/Presentation_final_4.13.pdf.
- 72 Awaaz.De is a technology company specialising in last mile communications to base of pyramid populations; in the D4Ag space Awaaz.De helps manage a number of agriculture advisory solutions in India, but also works as a technology partner with a number of D4Ag enterprises in Africa like Digital Green. See <https://www.awaaz.de>.
- 73 Arifu, which has nearly 1 million registered farmer users as of Q1 2019, positions itself as a smart personal learning companion and content marketplace that helps farmers (along with others) access free educational content over SMS and chatbot interfaces. Arifu, a B2B model that works with agribusinesses, financial institutions, and NGOs to support their farmer clients, initially focused on financial literacy education for smallholders but has over time developed a broader set of content on smallholder agronomy techniques for partners and clients like Syngenta Foundation and Safaricom's DigiFarm. While not a magic bullet for farmer engagement (depending on underlying quality of content and Arifu partners' business models for adding value to farmers), evaluations have shown that Arifu's model significantly improves farmer engagement and retention of content given the interactive design, behavioural nudge techniques, and participatory features (e.g., learning proceeds at farmers' pace and content is customised/adapted based on farmer responses in the chatbot). See <https://www.arifu.com/> and <http://pubdocs.worldbank.org/en/211611556636989321/2-Arifu-Overview-for-WB-DAT-Challenge.pdf>.
- 74 See <https://farm.ink/#> and <https://www.facebook.com/africafarmersclub/>. The enterprise reaches over 100,000 farmers today in Kenya; half of whom are active users on the platform.
- 75 MyAgriGuru uses natural local language interface text and voice chatbots to respond to farmer queries for advisory information and to facilitate plant disease diagnostics. In mid-2018 MyAgriGuru was being used by ~400,000 Indian smallholders and the solution is targeting 3 million users by the end of 2019. See <https://www.myagriguru.com>; see also <https://dribbble.com/shots/6474077-MyAgriGuru-India-s-1st-Agri-Advisory-Chat-Bot>.
- 76 Digital Green, founded in 2008, currently reaches nearly 2 million farmers globally of whom ~500,000 are in Africa, primarily in Ethiopia. For a selection of case studies and evaluations of Digital Green's participatory model, please see <https://www.digitalgreen.org/case-studies/>.
- 77 Started in 2015 in Kenya and now active in Kenya, Uganda, and Tanzania with more than 1.4 million farmers on the platform as of late 2018, WeFarm is built around the principle that rural farming communities in developing countries have generations worth of knowledge to share, but lack the tools to do so. WeFarm provides an SMS service based around peer-to-peer, crowdsourcing of knowledge. Users ask a wide range of questions regarding farming techniques and share information around business ideas, or how to improve livelihoods. See <https://wefarm.org/>.
- 78 N-Frnds, founded in 2014, and initially focused on Rwanda now has over 15 million registered users globally of whom a significant number (in the millions) re African smallholder farmers. The solution is a cloud-based digital distribution platform which utilises technology innovation (USSD 2.0) to enable farmers with feature phones to gain access to sophisticated interactive features even in the absence of mobile data, including group chat, email, and interactive agriculture advisory content (Nfrnds mAgri) which is deployed to local markets via MNO, agribusiness, and other B2B clients. Beyond its mAgri advisory application, Nfrnds is also used by agribusiness to manage agent networks and farmer interaction, such as, for instance, 200,000 farmers in the Rwanda potato value chain. For more details see <https://www.nfrnds.com>.
- 79 See, e.g., <https://www.businessdailyafrica.com/corporate/enterprise/WhatsApp-farmers-chatting-their-way-to-profits/4003126-5041800-131kw5z/index.html> and <https://ict4dblog.wordpress.com/2018/12/11/how-whatsapp-strengthens-livelihoods-of-women-farmers-in-rural-zimbabwe/>; see also https://www.researchgate.net/publication/326958580_WhatsApp_Model_for_Farmer_Led_Extension_Linking_Actors_and_Generating_Localized_Information_for_Farmers.
- 80 By some estimates, the number of Whatsapp users in Kenya is 8-10 million monthly vis-à-vis a total population size of 50 million (see <https://techweez.com/2018/11/02/kenyas-communication-authority-looking-into-whatsapp-regulation/> and Hootsuite, Digital 2019: Kenya report, available at <https://cnyakundi.com/state-of-the-internet-number-of-kenyas-active-twitter-monthly-users-drop-by-half-after-censorship/>).
- 81 See the GeoPoll Kenya smallholder survey of 900 farmers with phones chosen from a nationally representative 18,000 farmer panel (see <https://www.geopoll.com/blog/data-farming-kenya-mobile-phone/>). The survey results suggest that while 15% of Kenyan farmers were using "Farming Apps" a full 7% were using Whatsapp groups for the "farming needs" (likely including both information and market linkage uses).
- 82 Launched in 2018 by Intersoft Eagle, the SmartCow app offers the usual advisory features but also enables farmers to monitor their expenditure and income and to capture and analyse the history of each and every animal including the production levels for milk. See <http://farmbizafrica.com/machinery/1895-nairobi-company-launches-mobile-app-to-help-dairy-farmers-maintain-records>.



- 83 DigiCow, launched in Kenya in 2014 by Farmingtech Solutions, is a simple record-keeping app for dairy farmers which targets smallholder farmers and enterprises engaged in dairy farming enabling the farmer to increase their profits through data driven decision-making. The app's functionality is currently being expanded to enable farmer-to-farmer chat groups, market linkages (e.g., to vets), and linkages to financial providers. See <http://digicow.co.ke/>.
- 84 AgroInnova's AkokoTakra (2017) is a farm management software application for phones, tablets, and PC that enables Ghanaian poultry farmers to record, monitor, keep track and analyse all their farm operations easily including feed, drugs, birds, eggs collection, sales, and input purchases. See <https://www.akokotakra.com/>.
- 85 Launched in 2018 in Senegal, Sen Ngumu offers the solution to manage the entire production chain of one's poultry farm, adapted to poultry farmers at small scales. With their partners they offer a management solution, coaching and training and a management smartphone app with budgeting, planning, record-keeping, and advisory features. See <http://sennngumu.com/>.
- 86 Launched in 2017, Probity Farms is a simple advisory solution for smallholder farmers. It helps them plan their farm management, inventory management, and also their accounting. The solution is specially targeted towards those who are new to farming. The platform helps them make a business out of farming and guides them through the everyday activities of farm operations. See <https://probityfarms.com/>.
- 87 AgriGo, founded in 2016, is an advisory platform with some farm management components including recordkeeping of all farmer purchases and activities (tracked with USSD) and the ability to calculate costs of production and track expenses. AgriGo to date has signed up 30 cooperatives in Rwanda, through which they serve a total of 90,000 individual farmers and supports rice, maize, and potatoes. Revenue comes from account management fees (paid by cooperatives) or user subscription fees (paid by independent farmers). See <https://agrigo.rw/> and https://i2ifacility.org/system/documents/files/000/000/069/original/AgriGO_-_A_farmer's_financial_tool_to_grow_greater_financial_harvest_i2i_July_2018.pdf?1532604835.
- 88 Launched in 2017, BudgetMknoni is a farm budgeting and recordkeeping application for smallholder farmers launched by the iShamba team. See <https://budgetmknoni.com/>.
- 89 See <https://www.agrivi.com/en>.
- 90 See a general discussion of these factors at <https://dev.meas.illinois.edu/wp-content/uploads/2015/04/Ferris-et-al-2014-Linking-Farmers-To-Markets-MEAS-Discussion-Paper.pdf>.
- 91 For the most relevant overview to date of digital smallholder market linkage and e-commerce models, see Mercy Corps AFA & Dalberg. 2018. 'Benchmarking E-Commerce Models for African Smallholders', at https://www.findevgateway.org/sites/default/files/publication_files/afa_e-commerce_benchmark_slideshare_9.17_fnl.pdf; for other perspectives on the digital opportunity for input and off-take market linkages, see World Bank. 2016. 'Will Digital Technologies Transform Agriculture in Developing Countries?', available at <http://documents.worldbank.org/curated/en/481581468194054206/pdf/WPS7669.pdf>, and USAID. 2018. 'Where and How Digital Tools Impact the Value Chain', available at (https://www.usaid.gov/sites/default/files/documents/15396/Why_Where_and_How_Digital_Tools_Impact_the_Value_Chain.pdf).
- 92 Likely the best existing attempt to characterise digital market linkage business models are the MercyCorp AFA & Dalberg (2018), cited above, and AGRA. 2016. 'Digital Harvest', with the report available at https://www.raflelearning.org/sites/default/files/20161024_digital_harvest_final_report.pdf and case studies at https://www.raflelearning.org/sites/default/files/20160929_digital_harvest_case_studies_final.pdf.
- 93 See Ibid; see also the forthcoming research from MasterCard Foundation on digitally-enabled integrated value chain players like Tulaa and Safaricom's Digi-Farm (see <https://www.raflelearning.org>).
- 94 Farmers Pride (<https://farmersprideafrica.com/>), with ~10,000 smallholder farmers today leverages technology and franchising to give Kenyan farmers access to high quality inputs via an online mobile platform that connects farmers to the nearest verified vets, agronomy, inputs and insurance service providers, as well as real time climate information. The app platform also digitalises and links together existing village-level input shops thus combining the benefits of both digital and human linkages (see <http://pubdocs.worldbank.org/en/622751556637637102/Farmers-Pride.pdf>).
- 95 CowTribe(<https://www.cowtribe.com/>) is a Ghana-based for-profit organisation focused on supporting livestock farmers via a mobile platform that aggregates demand for livestock farming inputs and services, starting with vaccinations and veterinary services (DRK Foundation). CowTribe's service connects cows to vaccines and veterinarians. It is unique in West Africa and has attracted 30,000 users and substantial investment.
- 96 myAgro (<https://www.myagro.org/>) started in 2011 and now working with more than 50,000 farmers, is a mobile layaway commitment savings model for agri-input financing. myAgro operates by linking the aggregated farm input demand from smallholder farmers to high-quality input suppliers via local agro-dealer stores.
- 97 Agrics (<http://www.agrics.org/>), started in 2014 and initially supported by the Dutch G4AW programme, is a for-profit enterprise that is currently serving 35,000 farmers and generates revenue by procuring farm inputs in large quantities and selling them, on credit, with a target gross margin above 30%.
- 98 iProcure (<https://iprocu.re/>) is a digital B2B start-up working on optimising the agricultural input supply chain in Africa. The enterprise has established a network of 5000 farm input agro-dealers, which it supports with technology tools that help them improve their operations through business intelligence, improved inventory management, and streamlined distribution efficiency. iProcure is currently linking >25k farmers to inputs and has ambitious plans for scale and big scaling partners like Safaricom's DigiFarm.
- 99 For One Acre Fund's integration of digital technologies into their value chain approach, see USAID's 2017 case study of the organisation, available at https://www.usaid.gov/sites/default/files/documents/15396/One_Acre_Fund_Case_Study.pdf.
- 100 For a recent comprehensive profile of DigiFarm, see IFC. 2018. 'Digital Financial Services for Agriculture Handbook', available at https://www.ifc.org/wps/wcm/connect/4ca05121-fc39-42ae-891f-76203c7b91f0/Digital+Financial+Services+for+Agriculture_IFC%2BMCF_2018.pdf?MOD=AJPERES.
- 101 DigiFarm has registered roughly a million farmers in Kenya, but only a relatively small share of these clients is currently receiving inputs and input financing as the organisation scales up the market linkage element of its model; our interviews with the organisation and sector experts suggest a great deal of optimism for the platform's potential to generate more farmer engagement and scale as the value proposition gets further refined.
- 102 Twiga Foods (twiga.ke), founded in 2014, runs a mobile-based B2B food supply platform combined with physical infrastructure for farmer engagement, produce aggregation, and transport logistics that supplies fresh fruits and vegetables sourced from >16,000 farmers in rural Kenya to small- and medium-sized vendors, outlets and kiosks in Nairobi. Twiga is able to offer higher prices and a guaranteed market to farmers, and lower prices and a reliable supply to vendors. Twiga has raised more than \$35 million to date, a record for the African D4Ag sector. See GSMA. 2018. 'Twiga Foods', available



- at <https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2018/05/Twiga-Foods-Improved-market-access-for-farmers-and-a-reliable-supply-for-vendors.pdf>.
- 103 Selina Wamucii (www.selinawamucii.com/), has as its mission the integration of African smallholder farmers into high quality global supply chains for products like avocados, bananas, and fish, and is currently working in six African countries. Farmshine (www.farmshine.io/) helps smallholder farmers aggregate and sell their harvests directly to reliable commodity companies in Kenya with the help of field agents and a proprietary agent and buyer application. Taimba (www.taimba.co.ke) provides rural small-scale farmers in Kenya with direct linkages to urban traders. Similarly, Trade (www.tradeghana.co/) uses digital technology melded with a physical agent and storage warehouse network to play the role of maize value chain integrator in Ghana. Ninayo (<https://www.ninayo.com>) started as a virtual marketplace but has involved with more value additive intermediation activities.
- 104 See Digital Green Loop (www.getdoopapp.com) model overview in <https://www.digitalgreen.org/wp-content/uploads/2017/06/Digital-Green-Loop-brief-June2017.pdf>.
- 105 Tulaa (www.tulaa.io) has a unique digitally-enabled end-to-end value chain formalisation business model, currently reaching <5k farmers at the pilot stage. The company provides pre-screened quality inputs on credit to smallholder farmers based on a proprietary alternative data credit scoring tool, manages the logistics of input orders and delivery via its digital platform, and then brokers the sale of farmers' crops at harvest time. See brief Tulaa profile in CGAP. 2019. 'Fintechs and Financial Inclusion: Lessons Learned', available at: https://www.cgap.org/sites/default/files/publications/2019_05_Case_Study_Fintech_and_Financial_Inclusion.pdf; see also the forthcoming in-depth independent assessment of Tulaa's business model and economics from MasterCard Foundation's Rural Agriculture Finance Learning Lab (www.raflelearning.org/), Dalberg, and IDH.
- 106 Launched three years ago, Akorion (www.akorion.com) has at this stage reached ~60,000 farmers with its services working with a network of ~500 digitally-enabled village agents.
- 107 The FtMA (www.ftma.org), an alliance of eight agri-focused organisations, including large agribusiness partners, currently supports ~150,000 East African smallholder farmers "from seed to market" with inputs, finance, and market facilitation; of these ~60,000 are now supported via FtMA's digital platform. See MercyCorps AFA & Dalberg. 2019. 'FtMA Digitalization Lessons Learned', available at http://mercycorpsagrifin.org/wp-content/uploads/2019/01/AFA-FtMA_Digitization-and-lessons-learned_FIN.pdf.
- 108 For an overview of these models, see MasterCard Foundation RAFL. 2017. 'How can digital tools enable smallholder finance', available at <https://www.slideshare.net/MaliaBachesta/raf-ll-wapl-session-5>.
- 109 See, e.g., <https://www.theguardian.com/sustainable-business/2016/feb/11/internet-veg-box-schemes-africa-kenya-rwanda-gambia-farming>.
- 110 The AfDB estimated in 2017 that the African middle class is already 350 million people out of a total population of 1 billion (35%) and is likely to grow to 43% of the population by 2030, see https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/AEO_2017_Report_Full_English.pdf; alternative assumptions, like those from Credit Suisse lead to much more conservative numbers, but the continued growth of the middle class (in terms of both numbers and numbers) is incontrovertible.
- 111 See <https://www.rockefellerfoundation.org/blog/africas-farmers-ready-supermarkets-revolution/>.
- 112 The positive farmer value proposition is largely anecdotal but attested by many of our interviewees. In terms of reach, most of these models are still relatively small. While precise figures are not publicly available, we estimate that the dozen or so such businesses in our database work with 50,000 to 100,000 smallholder farmers across Africa, suggesting that most players are still quite small in their production volumes. The continued attention to such models from investors and a steady flow of publicly announced VC or follow on deals suggests, however, that the investment community sees viable economics and potential for greater scale.
- 113 For more details on a few of these types of enterprises, see, e.g., IzyShop (<https://izyshop.co.mz/>), FarmFresh (www.farmfresh.gm), HMart (www.shop.mart.rw), Foodstock (www.foodstock.com.ng/), Farmart (www.farmartghana.com), Khula (www.khula.co.za), and Herdy (www.herdy.co/).
- 114 For more information on these models see Afrimash (www.afrimash.com/), FarmIT (farmit.co.ke), and eMsika (www.emsika.com/).
- 115 See FAO (2013), where such electronic marketplaces are also labelled as virtual trading floors (VTFs).
- 116 For more details on the MasterCard Farmer Network (MFN), see <https://newsroom.mastercard.com/mca/press-releases/mastercard-recognised-with-best-agtech-solution-award-in-kenya/>.
- 117 Ninayo's (<https://www.ninayo.com>) original business model was fairly typical of such solutions. The service was set up as a two-sided virtual buy/sell platform, with ~25,000 farmers registered, in which farmers could advertise their crop holdings and buyers could advertise their crop needs. The two were able to find each other through an online interface (currently available only via smartphones, but with a USSD product in development), and could link up for the sale. In recent years Ninayo have been moving away from a pure marketplace model and has started to take on middleman trading functions via its own agents (i.e., migrating to an integrated off-take value chain model). For more information on other examples, see Usomi's Rubi (www.usomi.com/), Mifugotrade (<https://livestock.herokuapp.com/>), Farmster (www.farmster.co/), Animart (www.animart.com/), Zowasel (<https://www.zowasel.com/>), and eFarm (<https://www.efarm.cm/>).
- 118 See TruTrade (<http://www.trustradeafrica.net/>) and AgroTrade (<https://agrocenta.com/about>).
- 119 For more details, see FarmAll (<https://farmallke.com/>) and <http://www.agromarketday.com/>.
- 120 See Lima Links (<http://www.limalinkszambia.com/>) and Farmerline (<https://farmerline.co/>).
- 121 For more details, see Agrikore (www.cellulant.com/agrikore/).
- 122 See FAO. 2018. 'Sustainable Agricultural Mechanization: A Framework for Africa', available at <http://www.fao.org/3/CA1136EN/ca1136en.pdf>.
- 123 Ibid.
- 124 German Development Institute (GDI). 2017. 'Unlocking the Power of Irrigation for Sub-Saharan Africa', available at https://www.die-gdi.de/uploads/media/BP_7.2017.pdf; see also Liangzhi Y. *et al.* 2010. 'What is the irrigation potential of Africa', IFPRI.
- 125 Malabo Montpellier Panel. 2018. 'Mechanized – Transforming Africa's Value Chains', available at https://www.mamopanel.org/media/uploads/files/MaMo2018_Mechanized_Transforming_Africas_Agriculture_Value_Chains.pdf.



- 126 Ibid.
- 127 See, e.g., <https://www.aatf-africa.org/programmes/mechanization-and-digital-agriculture/>.
- 128 See an overview of this business model at <https://agra.org/news/uber-for-tractor-at-work/>.
- 129 See, e.g., <https://smartagripost.com/trimble-showcases-laser-land-leveller-for-chhattisgarh-farmers-promises-up-to-30-water-savings-10-gain-in-crop-yields/>.
- 130 Hello Tractor (www.hellotractor.com), founded in 2014 and with a reported client base of 250,000 African farmers, is an IoT platform that works across the entire tractor ecosystem from OEMs, to tractor distributors, to local tractor entrepreneurs/investments via digital applications that support fleet management, fleet monitoring, and shared economy tractor demand-matching services for farmers. HelloTractor allows farmers to rent tractors from owners for a predetermined amount of time and also stacks functionalities to increase value for its customers: it is a booking agent platform, offers alerts for maintenance and technicians to service the tractor, and utilises remote sensing to offer more in-depth analytics.
- 131 For further details on these models, which tend to focus more on digitalising the shared economy elements of mechanisation rather than the more B2B fleet management and IoT dimensions of Hello Tractor's model, see TroTro Tractor (www.trotrotractor.com), Kobiri (www.kobirigroup.com/), E-Tinga (www.e-tinga.com), and Farmall (farmallke.com).
- 132 See Trringo (www.trringo.com); several thousand farmers already using the service in Tanzania.
- 133 See M-KOPA Solar (<http://www.m-kopa.com/>), Fenix International (<https://www.fenixintl.com/>), BBOX (<https://www.bbox.co.uk/>), Zola Electric (<http://zolaelectric.com/>), and PEG Africa (<https://pegafrika.com/>).
- 134 PAYG solutions had an estimated reach of 2 million African households in early 2018; see overview of sector in the GOGLA/Dalberg. 2018. 'Off-grid Solar Market Trend Report' (<https://www.lightingglobal.org/2018-global-off-grid-solar-market-trends-report/>).
- 135 For more details on SunCulture, see <http://sunculture.com/>.
- 136 For more information, see Azuri (<https://www.azuri-technologies.com/>), SimuSolar (<https://www.simusolar.com/>), AgSol (<https://agsol.com/>), and ColdHubs (<http://www.coldhubs.com/>).
- 137 See the forthcoming WB & Dalberg report on Productive Use Leveraging Solar (PULSE) in mid-2019.
- 138 See, e.g., discussion in USAID Feed the Future. 2018. 'Policy Brief #5: ICT Solutions for Inclusive Agriculture Value Chains'. See also World Economic Forum (WEF). 2019. 'Innovation with a Purpose: Improving Traceability in Food Value Chains through Technology Innovations' (http://www3.weforum.org/docs/WEF_Traceability_in_food_value_chains_Digital.pdf).
- 139 African agribusiness surveys consistently highlight growing investment into technology solutions as a major area of challenge and opportunity. The 2016-2017 PWC Africa Agribusiness survey, for instance, highlighted technology access as the top challenge for the sector. Top priority technology innovations targeted by agribusinesses for investment in the survey included digital tools for demand forecasting, inventory management, digital track and trace methods to improve food safety, and digital communication and monitoring tools that can facilitate greater connectivity with smallholder farmers and field agent forces. PWC. 2017. 'Africa Agribusiness Survey (2016/2017)' (<https://www.pwc.co.za/en/assets/pdf/agri-businesses-insights-survey-may-2016.pdf>); the 2017/2018 survey is available at <https://www.pwc.co.za/en/assets/pdf/africa-agribusiness-insights-survey-2017-2018.pdf>.
- 140 This discussion draws heavily on GSMA. 2018. 'The role of digital in improving traceability and certification in the agricultural last mile' (<https://www.gsma.com/mobilefordevelopment/blog-2/the-role-of-digital-in-improving-traceability-and-certification-in-the-agricultural-last-mile/>).
- 141 For example, 10 of 16 digital Africa-centred "tracking and traceability" solutions reviewed last year by USAID were export focused. See USAID Feed the Future, "Policy Brief #5: ICT Solutions for Inclusive Agriculture Value Chains" (2018).
- 142 The importance of sustainability and thus track and trace digital solutions highlighted in PWC 2016 and 2017 surveys (see note 139).
- 143 Ibid.
- 144 For more information on these players, see SourceTrace (www.sourcetrace.com), SourceMap (www.sourcemap.com), EProd (www.eprod-solutions.com), and FarmForce (<https://farmforce.com/>).
- 145 See <https://www.sap.com/products/agriculture-supply-chain-mgmt.html>.
- 146 See <https://blog.chainpoint.com/blog/the-rainforest-alliance-selects-chainpoint-as-central-data-collection-platform-in-sustainable-supply-chains>.
- 147 NamLITS was launched by the Namibian government in 2006 for commercial farmers and extended to communal livestock farmers in 2014, which proved to be a fortuitous bit of timing. A recent evaluation has found that during the 2015 foot and mouth disease outbreak in the country, the worst such outbreak in 40 years, NamLITS was used to minimise the impact of this outbreak and made free trade possible once again by using its advanced functionalities illustrating its effectiveness. See Prinsloo *et al.*, "The role of the Namibian Livestock Traceability Systems in containing the recent foot-and-mouth disease outbreak," NextComp (2017), available at <https://ieccexplore.iecc.org/document/8016172>.
- 148 See Ashour *et al.*, "An Evaluation of the Impact of E-verification on Counterfeit Agricultural Inputs and Technology Adoption in Uganda", IFPRI (2015), available at <http://www.ifpri.org/publication/evaluation-impact-e-verification-counterfeit-agricultural-inputs-and-technology-adoption>.
- 149 See DeBouef *et al.*, "Counterfeiting in African Agriculture – Challenges and Solutions," Bill and Melinda Gates Foundation (2014), available at <https://www.agrilinks.org/library/counterfeiting-african-agriculture-inputs-challenges-and-solutions>
- 150 DeBouef *et al.* (2018).
- 151 See QualiTrace (www.qualitracegh.com/about/).
- 152 See mPedigree (<https://mpedigree.com>) and Sproxil (<https://www.sproxil.com/>) for more details on such input verification business models and underlying technologies.
- 153 LORI (<https://www.lorisystems.com/>) and Kobo360 (<https://www.kobo360.com/>) models do already have relevance for African agriculture, with Kobo360 for example exploring partnerships with a number of agribusiness players in West Africa.
- 154 See iProcu (<https://iprocu.re/>), Logistimo (<https://www.logistimo.com>), and Virtual City (<http://www.virtualcity.co.ke>), and WeightCapture (<http://www.weightcapture.com/>).



- 155 See iProcure (<https://iprocu.re/>).
- 156 For some illustrative data on the potential impacts of such solutions, see the self-reported impact reporting by Virtual City, available at <https://www.virtualcity.co.ke/solution/agroforce-2/>.
- 157 See, e.g., <https://www.sap.com/products/what-is-erp.html>.
- 158 For Africa-based, see Farmforce (<https://farmforce.com/>), EProd (<http://www.eprod-solutions.com/>), Metajua (<http://metajua.com/>).
- 159 TaroWorks (<https://taroworks.org>) started a digital field force tracking and management tool incubated from Grameen Foundation's CKW advisory services model in Uganda, but has evolved into a stand-alone digital field force management and ERP solution with features like order management, location mapping, and CRM.
- 160 See SourceTrace (<http://www.sourcetrace.com/apps/>), CropIn (<http://www.sourcetrace.com/apps/>), and Annona (<https://annona.co/>).
- 161 See <https://www.accenture.com/us-en/insight-accenture-digital-agriculture-solutions>.
- 162 Vodafone's Connected Farmer grew out of Vodafone's role as part of the Connected Farmer Alliance. While the product is marketed as a standalone service in South Africa, in East Africa this offering is embedded in Digifarm as the B2B dimension of Digifarm's technology stack. See <https://www.vodacombusiness.co.za/business/solutions/internet-of-things/agriculture/connected-farmer>.
- 163 See <https://www.olamgroup.com/sustainability/reimagine/olam-farmer-information-system.html>.
- 164 Much of this discussion draws on IFC. "Handbook: Digital Financial Services for Agriculture" (2018), available at https://www.ifc.org/wps/wcm/connect/region_ext_content/ifc_external_corporate_site/sub-saharan+afrika/resources/dfs-agriculture; see also MCF RAFFL, "Inflection Point: Unlocking Growth in the Era of Farmer Finance" (2016).
- 165 For the older Inflection Point reports that have proved critical to framing the dialogue around financial services for agriculture, see <https://www.rafflearning.org/post/inflection-point-unlocking-growth-era-farmer-finance>. For the most comprehensive recent report on this topic, see also IFC. "Handbook: Digital Financial Services for Agriculture" (2018), available at https://www.ifc.org/wps/wcm/connect/region_ext_content/ifc_external_corporate_site/sub-saharan+afrika/resources/dfs-agriculture.
- 166 For the category of traditional financial service providers who are digitalising their business models it is often difficult to define the boundary line between those enterprises that can be classified as D4Ag solutions and those that are simply financial service providers who happened to digitalise some of their approach. To ensure clarity of definition and scope, the report tries to focus only on those institutions that have truly distinct digital products – digital channel, digital branding, heavily digitalised operations – rather than the delivery of traditional financial products with some digitalisation of background processes (e.g., SMS notifications for customer management) or background analytics tools (e.g., new credit scoring algorithms that include digital data streams).
- 167 World Bank Global Findex, 2017.
- 168 Better Than Cash Alliance (BTCA). "The Role of Digital Payments in Sustainable Agriculture and Food Security" (2017), available at https://btca-prod.s3.amazonaws.com/documents/313/english_attachments/Agriculture_Report.pdf?1508858199.
- 169 GSMA (2016), available at <https://www.gsmainelligence.com/research/?file=29e480e55371305d7b37fe48fb10cd6&download>.
- 170 See IFC. "Handbook" (2018), full citation in note 100; see also BTCA (2017).
- 171 See BTCA (2017); see also GSMA, "Market size and opportunity in digitising payments in agricultural value chains" (2016), (<https://www.gsmainelligence.com/research/?file=29e480e55371305d7b37fe48fb10cd6&download>).
- 172 As part of its work under GES in 2012 through the end of the scheme in 2017, and in collaboration with the Nigerian Central Bank, Cellulant registered 17 million farmers in the country and channelled nearly \$1 billion of input subsidies to 7 million of these farmers, achieving very high levels of linkage and uptake to agricultural input purchases. The programme was discontinued when the government subsidy scheme lapsed and Cellulant has since pivoted its model, but the example of GES is still a notable one. See <https://cellulant.com/blog/agritech-in-africa-how-an-e-wallet-solution-powered-nigeria-governments-ges-scheme/>.
- 173 Zoono's (<https://lovezoono.com/>) model has evolved significantly in recent years, but the organisation is at its core a third-party provider of mobile payments focused on building a reliable, cash-in/out network and facilitating B2C and B2B payments. In agriculture, Zoono's model was at one stage a major channel for G2P payments to farmers and later B2P payments as lead firms that contract with thousands of farmers use Zoono to reduce individual payments; the agribusiness makes one payment to Zoono, which then make e-voucher or mobile payments to each of the contracted farmers that can be redeemed with input retailers or cash-in/out agents.
- 174 See note 28 for an overview of SNS (<https://smartnkunganire.rw/>). SNS was intentionally designed to first serve as a payments and supply chain management tool for Rwanda's national agro-input subsidy programme with the objectives of improving the programme's efficiency, productivity, and transparency. Now that the system is in place, however, the model is evolving to give each farmer in the SNS system an 'IKOFI' universal digital wallet that allows farmers to send and receive money (zero transaction fee), pay agro-dealers, receive payment for their harvest, pay into the national long-term savings scheme, and ultimately pay for health care and other services via a phone (USSD/SMS) while also generating a valuable financial track record that can serve as a gateway to other financial services. See <https://ktpress.rw/2019/05/bank-of-kigali-launches-ikofito-boost-agriculture-financing/>.
- 175 An astonishing 20% of SmartMoney's rural customers make digital payments for goods and services in their daily lives and input payments are fully digitalised in most SmartMoney communities.
- 176 This discussion draws heavily on IFC. 2018. 'Handbook', full citation in note 100.
- 177 See, e.g., evidence on the impact of savings (regular and commitment savings accounts) on farmer investments, yields, and incomes in Brune, L. *et al.* 2015. 'Facilitating Savings for Agriculture: Field Experimental Evidence from Malawi', *NBER Working Paper No. 20946* (<https://www.nber.org/papers/w20946>).
- 178 See World Bank. 2017. *Global Findex 2017*. Where data is available, unsurprisingly, savings access levels are even lower for smallholder farmers than for the population at large. CGAP's smallholder farmer diaries show savings access levels of ~10% (5-20% range) for formal savings accounts and ~15% (5-25%) for informal savings clubs across countries like Uganda, Tanzania, Mozambique, Nigeria, and Côte d'Ivoire (see https://www.cgap.org/sites/default/files/small_holders_data_portal/).



- 179 See notes 172-174 for information on Cellulant, Zoono, and SNS e-wallet models.
- 180 See <http://fizambia.com/?p=1464>.
- 181 Currently 35% of the Agri-Wallet (<https://agri-wallet.com/>) farmers who use the wallet, save. As part of an 'ecosystem' with earmarked credit, Agri-wallet helps farmers to save and in turn enables them to access short term loans through Rabobank. See <https://www.cta.int/en/digitalisation/all/article/agri-wallet-a-wallet-for-smallholder-farmers-sid00f60f624-f62a-4b58-bd27-bd2c838b724f>.
- 182 See myAgro (<https://www.myagro.org/>); see also IFC. 'Handbook' (2018), full citation in note 100.
- 183 <https://www.akdn.org/our-agencies/aga-khan-foundation/akf-digital-savings-groups-dsg>.
- 184 <https://akaboxi.com/>
- 185 In 2016, Dalberg and ISF estimate a \$200 billion global smallholder financing demand and a \$150 billion financing gap. Using the Sub-Saharan Africa smallholder household population as proxy relative to the global smallholder farmer population and a 5-10% credit access estimate for African smallholders, we estimate that the Africa share of the gap is roughly 25%, i.e., roughly \$25-35bn (□30bn). See MCF RAFL. 2016. 'Inflection Point Report'.
- 186 One Acre Fund. 2016. 'Scaling up agricultural credit in Africa', available at https://oneacrefund.org/documents/104/Scaling_Up_Agricultural_Credit_In_Africa_Farm_Finance.pdf.
- 187 See, e.g., Dalberg & MCF RAFL. 2018. 'Big data could mean big opportunity: why we should stay excited for data analytics in smallholder finance.' (https://www.rafllearning.org/sites/default/files/learning_brief_5_-_data_analytics-final.pdf?token=g6FuZCx4); see Dalberg & MCF RAFL. 2016. 'The business case for digitally enabled smallholder finance.' (<https://www.rafllearning.org/post/learning-brief-1-business-case-for-digitally-enabled-smallholder-finance>).
- 188 For more on digital smallholder loan innovation from banks like KCB, Advans, and Opportunity International, see MCF RAFL. 2017. 'Case for digitalising smallholder finance'.
- 189 Digital MFI Musoni's Kilimo Booster, for example, offers a flexible digital loan with grace periods and repayment plans tailored to the individual farmers' production circumstances coupled with a fully digital field registration, loan disbursement and repayment experience. Musoni found that in addition to offering loans to farmers on terms that set them up for successful repayment, the digital platform allowed them to easily "deliver additional services via mobile, without having to constantly make changes to the core banking system." IFC (2018).
- 190 Akelobanker (<http://www.akelobanker.com/how-it-works>) offers easy access to tractor hire, improved seed, medical services and farm labour on credit, by leveraging data and mobile technology to offer structured re-payments compatible to the user's needs. The platform integrates mobile money and use of USSD to facilitate instant access, disbursements and repayments. The technology uses the historical data collected to generate automated digital credit scores.
- 191 See note 105.
- 192 See <https://apolloagriculture.com/>.
- 193 For the note of caution on the potential viability of these models see IFC. 2018. 'Handbook' (full citation in note 100). Ongoing portfolio analyses by Dalberg, IDH, and the MCF Rural Agriculture Finance Learning Lab of organisations like Tulaa, Opportunity International, and Digifarm (publications forthcoming in 2019) suggest, however, that despite many unanswered business models' questions and challenges, at their core these models can be a viable pathway to both scale and sustainability.
- 194 Ibid. See also AFL. 2017. 'Digitally Delivered Credit: Consumer Protection Issues and Policy Responses to New Models of Digital Lending.' (<https://www.afi-global.org/publications/2633/Digitally-Delivered-Credit-Consumer-Protection-Issues-and-Policy-Responses-to-New-Models-of-Digital-Lending>).
- 195 See overview of crowdfunding models in Nigeria that informs this discussion at ICT4DBlog. 2018. 'Crowdfarming platform enabled investment into Nigerian Agriculture' (<https://ict4dblog.wordpress.com/2018/11/20/crowdfarming-platform-enabled-investment-in-nigerian-agriculture/>).
- 196 See <https://techpoint.africa/2018/03/12/farmcrowdy-office-tour/>.
- 197 See <http://www.farmable.me/>.
- 198 ICT4DBlog (2018).
- 199 Ibid.
- 200 For more details on FarmCrowdy's (<https://www.farmcrowdy.com/>) model, see Ibid. See also: <https://www.coruscatesolution.com/create-farmcrowdy-app-clone/>.
- 201 See Growsel (<https://www.growsel.org/>), Thrive Agric (<https://www.thriveagric.com/>), Livestock Wealth (<https://www.livestockwealth.com/>), and Bayseddo (<https://www.bayseddo.com/>).
- 202 This discussion draws on the best recent overview of the insurance opportunity for smallholder farmers, see Initiative for Smallholder Finance (ISF). 2018. 'Protecting growing prosperity: Agricultural insurance in the developing world.' (https://www.rafllearning.org/sites/default/files/sep_2018_isf_syngenta_insurance_report_final.pdf?token=1i4u5GwD).
- 203 Ibid.
- 204 IFC. 2018. 'Handbook' (full citation in note 100).
- 205 For 3% estimate, see ISF. 2018. 'Protecting prosperity'. Earlier estimates have been 6%. IFC. 2018. 'Handbook' (see note 100).
- 206 Ibid.
- 207 For an overview of these models, see ISF. 2018. 'Protecting growing prosperity'. For details on each, see Pula (<https://www.pula-advisors.com/>), ACRE Africa (<https://acreffrica.com/>), Oko (<https://www.oko.finance/>), and World Cover (<https://www.worldcovr.com/>).
- 208 SumAfrica is a Netherlands G4AW-supported programme, now on a commercial basis, that involves a consortium of a local insurer in Uganda (Ugandan Agro Insurance Consortium (AIC)) and the Dutch company EARS, which develops and provides the satellite-based drought index. See <https://g4aw.spaceoffice.nl/en/projects/g4aw-projects/62/scaling-up-micro-insurance-in-africa-sum-africa-.html>; see also, <https://www.propertycasualty360.com/2019/02/12/sum-africa-project-offers-unique-insurance-service-to-farmers-in-uganda/?slreturn=20190427213616>.



- 209 See <http://www.winners-project.org/>.
- 210 IFC. 2018. 'Handbook' (see note 100).
- 211 See in-depth discussion in Dalberg & MCF RAFLL publications on these topics in note 187.
- 212 See an overview of such models in a recent study by Dalberg and MCF RAFLL, available at <https://www.rafllearning.org/post/learning-brief-5-big-data-could-mean-big-opportunity-why-we-should-stay-excited-for-data>.
- 213 For details on each of these players, see FarmDrive (<https://farmdrive.co.ke/>), Harvesting (<https://harvesting.co/>), YAPU (<https://www.yapu.solutions/>), and SatSure (<https://www.satsure.co/>).
- 214 See <https://www.rabobank.com/en/about-rabobank/in-society/rabobank-foundation/index.html>.
- 215 CTA. 18/04/2018. 'Input loans boost farmer take-up rates for satellite-based advisory service' (<https://www.cta.int/en/digitalisation/all/article/input-loans-boost-farmer-take-up-rates-for-satellite-based-advisory-service-sid0c75ed4b1-173d-4c1d-a899-be03866bd3f3f>).
- 216 CTA (forthcoming). Study on perceived change on credit-worthiness by financial or lending institutions of smallholder farmers availing comprehensive and up-to-date farm data sets including spatial data.
- 217 See <https://ensibuuko.com/>.
- 218 A major source for this section is USAID. 2018. 'Data Driven Agriculture', available at (https://www.usaid.gov/sites/default/files/documents/15396/Data_Driven_Agriculture_Farmer_Profile.pdf).
- 219 The platform builds capacity throughout the CGIAR to generate and manage big data, assisting CGIAR and its partners' efforts to comply with open access/open data principles to unlock important research and datasets. See <https://bigdata.cgiar.org/about-the-platform/>.
- 220 See <https://theodi.org/topic/agriculture-and-food/>.
- 221 <http://www.data4sdgs.org/>.
- 222 GODAN, launched in 2013, is a sector coalition that is working toward the aim of making agricultural and nutritional data more available, accessible, usable, and unrestricted worldwide. GODAN is the leading sector association on Data4Ag issues and has seen particularly accelerated growth in the past few years, from ~350-400 members in 2017 to 920+ in April of 2019. See <https://www.godan.info/>.
- 223 Powered by weather data from aWhere and many other data sources, the WB Ag Observatory is both an internal function/service for the World Bank Group and an outwardly facing tool and capacity-building entity for governments throughout Africa. The observatory has as its mission the focus on harnessing big data, artificial intelligence, and machine learning for productive and resilient agriculture worldwide through better agriculture sector decision-making. See the WBG Ag Observatory overview presentation available at: <https://olc.worldbank.org/system/files/Harnessing%20Big%20Data%2C%20Artificial%20Intelligence%20and%20Machine%20Learning%20for%20productive%20and%20resilient%20agriculture.pdf>.
- 224 See <http://kaop.co.ke/>.
- 225 <http://few.net/about-us>.
- 226 <http://geoglam.org/index.php/en/global-regional-systems-en/crop-monitor-for-amis>.
- 227 See <http://dataviz.vam.wfp.org/>.
- 228 For more information about the CropWatch Mozambique tool, see <https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/E-agriculture-Solutions-Forum-2018/CropWatch%20for%20ESF.pdf>.
- 229 See <https://gro-intelligence.com/about>.
- 230 TCS (<https://www.tcs.com>) has developed an agricultural analytics engine called agEYE™, along with a web-based application that provides historic, current, and future data on crops. The application offers crop health, soil moisture, weather forecast, disease severity forecast, and disease identification at a village level to farmers and other stakeholders in the agri-value chain, including macro agri-decisionmakers. These parameters are derived from near real-time remote sensing data and weather data from third-party service. The service is primarily deployed in India, but has also seen some adoption in South Africa pilots.
- 231 See <https://6grain.com/>.
- 232 See <https://www.mckinsey.com/solutions/acre>.
- 233 See <https://bigdata.cgiar.org/inspire/inspire-challenge-2018/cubica-the-new-farmer-advisory-app/>.
- 234 <https://www.satsure.co/>.
- 235 <https://satelligence.com/>.
- 236 See <https://www.microsoft.com/en-us/ai/ai-for-earth?activetab=pivot1%3aprimar6>.
- 237 See <https://earthengine.google.com/>.
- 238 For the MercyCorp AgriFin definition of 'Super Platforms', see CGAP. 2018. 'Super Platforms: Connecting Farmers to Markets in Africa', available at <https://www.cgap.org/blog/super-platforms-connecting-farmers-markets-africa>). This CGAP blog post, and the underlying Dalberg & MercyCorps AFA 'Digital marketplace benchmarking report' it referred to, frame the 'super platform' concept more narrowly than this report. The digital marketplaces in question have all key features we have highlighted for super platforms, but all are commercial enterprises with e-commerce, or e-commerce combined with payments, at their core. While e-commerce, or rather buyer-seller digital marketplaces, needs to be a key component of super platforms, we believe that there are many more variants of such models including government- and donor-led platforms with digital marketplace components (e.g., SNS Rwanda, FtMA Rwanda) and bank-led models (e.g., KCB/MobiGrow).
- 239 For holistic Service Delivery Models (SDM), see the forthcoming case studies on SDM models from MasterCard Foundation, IDH, and Dalberg at <https://www.rafllearning.org/post/the-business-case-smallholder-finance-introducing-the-sdm-case-study-series>); for integrated digital marketplaces, see MercyCorp AFA & Dalberg. 2018. 'Digital marketplace benchmarking report'.



- 240 See emerging insights coming out of Dalberg, IDH, and MCF RAFLI studies of integrated market linkage models with Super Platform features (e.g., Digifarm, Tulaa) (<https://www.rafllearning.org/post/the-business-case-smallholder-finance-introducing-the-sdm-case-study-series>).
- 241 While SNS was built and is being managed by the Bank of Kigali (BoK)/TecHouse, the system is governed jointly by BoK and the government of Rwanda via the Rwanda Agriculture Board (RAB). SNS already covers elements of advisory services (i.e., SMS-based advice and alerts to 1.4 million farmers) and financial access (i.e., B2P, G2P, C2C payment functionality, universal e-wallet, BoK savings accounts), market linkages (agro-dealer linkage as part of the subsidy programme), and supply chain management. The next steps in the system's evolution include insurance product distribution, the provision of credit products via BoK, and an off-take market linkage virtual digital marketplace. See <https://smartnkunganire.rw>.
- 242 As part of the recently launched and BMGF-funded Digital Green advisory data ecosystem consortium in Ethiopia, ATA will be looking at opportunities to integrate or link major national assets including national digital advisory infrastructure (e.g., 80-28 hotline), digital payments and e-wallet for agriculture (e.g., potential partnership with Ethiotelcom), and perhaps market linkage initiatives.
- 243 See <https://www.enam.gov.in/>.
- 244 See <https://ftma.org/>; see also note 105 for details.
- 245 KCB, East Africa's largest commercial bank, entered into a \$27 million partnership with MasterCard Foundation in mid-2018 to promote financial inclusion for at least 2 million smallholder farmers in Kenya and Rwanda. In addition, KCB group committed at the time to extending at least ~\$180 million to farmers in the two countries in affordable loans over a five-year period. Today, the digital MobiGrow product already reaches 380,000 farmers, with a plan to reach 1.5-2 million more in the next few years. (<https://ke.kcbgroup.com/business/agri/MobiGrow>).
- 246 GSMA. 2016. 'Market size and opportunity in digitising payments in agricultural value chains.' (<https://www.gsma.com/mobilefordevelopment/resources/market-size-and-opportunity-in-digitising-payments-in-agricultural-value-chains/>).
- 247 Digifarm has already registered 950,000 farmers by early 2019, though the number of clients using market linkages and receiving credit is still relatively low at this early stage of the product's build-out. The platform is continuing to grow and evolve in terms of its reach and functionality.
- 248 See <https://www.ecofarmer.co.zw/value-chain-services>.
- 249 MFN (<https://www.mastercard.us/en-us/about-mastercard/corp-responsibility/social-sustainability/the-mastercard-labs-for-financial-inclusion.html>) is a platform that digitises marketplaces, payments, workflows and farmer financial histories within the agriculture sector. MFN increases farmer linkages to markets and formal financial services relevant to their needs and aspirations. The platform brings together various agri-sector stakeholders, such as farmers, farmer producer organisations, buyers, financial institutions and value-added services providers, amplifying the collective positive impact on farming communities.
- 250 See, e.g., <https://www.awhere.com/muis-project-in-uganda-transitions-to-a-business-that-helps-farmers/>.
- 251 See in-depth profile in Olam. 2019. *Olam Insights, May 2019* (https://www.olamgroup.com/content/dam/olamgroup/investor-relations/ir-library/olam-insights/olam-insights-pdfs/Olam_Insight2019_Issue1.pdf).
- 252 The Figure illustrating Taobao's model and the related text below draw on several sources. See, e.g.: World Bank. 2019. 'E-commerce for poverty alleviation in China' (<http://blogs.worldbank.org/castasiapacific/e-commerce-poverty-alleviation-rural-china-grassroots-development-public-private-partnerships>); Su, Q. & Yan, D. 2018. 'Rural Taobao yields benefits for farmers by analyzing big data', *China Daily Asia* (<http://epaper.chinadailyasia.com/asia-weekly/article-13996.html>); Xinxua. 2017. 'China's prominent techfin shares rural poverty alleviation lessons with FAO.' (http://www.xinhuanet.com/english/2017-07/15/c_136446325.htm); Ding, D. et al. 2017. 'From Ant Financial to Alibaba's Rural Taobao Strategy - How Fintech Is Transforming Social Inclusion.' https://www.researchgate.net/publication/328274301_From_Ant_Financial_to_Alibaba's_Rural_Taobao_Strategy_-_How_Fintech_Is_Transforming_Social_Inclusion; 2017. Chen, J. 2017. 'Ant Financial: Our rural china practice'. (<https://www.slideshare.net/ExternalEvents/ant-financial-our-rural-finance-practice>); Alibaba. 2016. 'Rural Taobao Overview.' <https://www.alibabagroup.com/en/ir/pdf/160614/09.pdf>.
- 253 Ibid.

Chapter 3

- 254 FAO launched the e-agriculture community of practice in 2002, which we believe was one of the first formal conversations around D4Ag, following soon after the start of GSMA's mAgri programme in late 2001. While our database does not go back far enough, GSMA's no-longer functional 'mAgri' tracker documented fewer than 10 D4Ag solutions in Africa prior to 2005 and 66 D4Ag solutions by 2010 (not directly comparable to our database number).
- 255 This analysis is primarily based on self-reported survey data and desk research and is not exhaustive of all current and prior D4Ag activity in Africa. As a result, the figures across all years are likely understated – particularly the data for the earliest years, given that a significant (though uncounted) number of solutions have gone out of business. Using the number of solutions captured in the GSMA mAgri data tracker in 2012 to adjust for this survivorship bias yields a CAGR of 35% in terms of the number of solutions, rather than 45% calculated based on our database. While the figures are not exact, they help illustrate the likely growth trajectory of the sector over the last 7+ years.
- 256 We estimate that the database currently captures only 90-95% of the relevant solutions in the space given the difficulty of tracking very new start-ups. Approximately seventy D4Ag enterprises in our D4Ag database are now defunct, but there is a strong survivorship bias in the data. Comparison to earlier estimates by GSMA and others suggests there are likely another 50-100 defunct solutions that have not been reflected in our data. Most of these defunct organisations were part of the advisory services use case and were launched before 2015.
- 257 This includes solutions that were launched in the first few months of 2019 prior to the finalisation of this report.
- 258 Our database captured ~360 unique companies that offered these 390 solutions. Roughly 15 enterprises offered more than one solution, ranging from two up to 12 solutions (e.g., both Viamo's '3-2-1' services and Orange's mAgri services comprise over 10 solutions in partnership with other organisations across the Sub-Saharan Africa region).
- 259 While data are spotty for these kinds of projects, directional estimates provided in interviews by major agriculture sector funders in Africa – such as BMGF, WB/IFC, USAID, GIZ, DFID and the EU – or implementers like Mercy Corps suggest



- that the number of donor-funded D4Ag projects or projects with D4Ag components is growing rapidly. For instance, a review of World Bank agriculture projects a few years ago concluded that ~80% had some sort of digital component (e.g., use of SMS for M&E) (WB interview (2019)).
- 260 More so than other use cases, the financial access category presents quite a few definitional challenges in terms of where the border should be drawn between D4Ag financial access solutions and financial service providers and products that (i) are not sufficiently agricultural (i.e., are not tailored to the needs of smallholder farmers even if they happen to be used by smallholder farmers and (ii) are not sufficiently digitalised (e.g., traditional banks that have started to introduce digital channels for client communications). Our database, for instance, excludes digital payment solutions that are not specifically crafted for smallholder farmers (e.g., M-Pesa). Likewise, the database excludes banks and MFIs who have started to digitalise some of their operations but have not launched fully digital products, i.e., those that are not branded as being digital, or still require significant in-person interaction.
- 261 The macro agri-intelligence number appears artificially low in this analysis. There are many D4Ag solutions (60+) that have macro agro-intelligence components, but where macro agri-intelligence is just a secondary or ancillary revenue stream and not the primary focus of the enterprise and hence is not shown here.
- 262 The 44% figure over the past three years is the self-reported growth in farmer registrations among the Dalberg-CTA D4Ag survey respondents; the 55% CAGR over the past eight years is based on a roughly estimated 1 million farmers registered for D4Ag solutions in Africa in 2010–2011 based on desk research and the GSMA mAgri tracker.
- 263 Dalberg-CTA database analysis triangulated with interviews and desk research (see Methodology appendix).
- 264 There are an estimated 73 million smallholder farmer households (63 smallholder households plus 10 million pastoralists households) and 250 million total smallholder farmers (190 million smallholder farmers plus 60 million pastoralists) in Sub-Saharan Africa (See Lowder, S.K. *et al.* 2016. 'The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide'. *World Development* (www.sciencedirect.com/science/article/pii/S0305750X15002703) and the Methodology appendix in this report). These values yield a penetration in the range of 13–45% for registered smallholder farmers depending on the denominator used (i.e., share of all farmers or share of smallholder farmer households).
- 265 Our database captured a very small number of agents as registered farmers due to reporting errors – but this number should be negligible and a rounding error, likely on the order of a maximum of a few thousand users.
- 266 In areas where many D4Ag solutions have expanded rapidly (e.g., Kenya), duplicate registrations could account for as much as 30–40% of the total registration count based on our comparisons of total estimated country level registrations vs. the share of farmers reporting the use (at any point) of D4Ag services. In locations with few D4Ag solutions, duplicated registrations likely account for fewer than 10% of the total registration count. Given the fact that Kenya is exceptional in its levels of D4Ag solution penetration and use, we assume that a maximum of 20% of farmer registrations were duplicates across the region, yielding an estimate of approximately 26 million *unique* farmers registered for D4Ag solutions in Sub-Saharan Africa. However, given our inability to estimate this number with confidence, we use the total number of registrations – 33 million – for the remainder of the report.
- 267 Please see Annex for a detailed methodology behind calculations for MNO, agribusiness, and FSP reach.
- 268 These include Econet, MTN, Orange, Airtel, and Safaricom/Vodafone. In addition to their own mAgri deployments, Orange and Vodafone have also launched mAgri solutions in partnership with other players (i.e., Orange has partnered with Brastorne Partners and Viamo; and Vodafone has partnered with Esoko in Ghana).
- 269 Interviews and desk research; see, e.g., Askew, K. 2018. 'From 'revolutionary' tech to empowering farmers: How Olam leverages its African footprint to improve cocoa sustainability'. *Food Navigator* (www.foodnavigator.com/Article/2018/09/27/How-Olam-leverages-its-African-footprint-to-improve-cocoa-sustainability).
- 270 We base this figure on publicly available data, survey data from the CTA-Dalberg survey, and expert assessments from interviews; as the information is not publicly revealed in some cases; there is a wide range of uncertainty around this number.
- 271 These numbers are particularly challenging to come by as most agribusinesses do not directly report the number of farmers reached by their digital offerings, and many have just announced plans to introduce D4Ag services to their farmers.
- 272 The definition of 'engaged user' includes users who were defined by the surveyed D4Ag enterprise as being 'active'. The definition of active is subjective, but exceeds the use of the solution once per month during the crop season for advisory, market linkage, and supply chain management solutions. For financial services, this definition was less applicable – a farmer may only use the solution once but still be active or a customer in good standing – for instance, in the case of a digital savings account, digital credit product or agri-index insurance.
- 273 GSMA has conducted case studies of M-Kilimo in Kenya (2011), Airtel M'chikumba 212 in Malawi (2017), Orange Senekela in Mali (2015), and Tigo Kilimo in Tanzania (2015). GSMA website (www.gsma.com/mobilefordevelopment/resources/mfarmer-case-studies).
- 274 Note that these are not unique users, as some farmers may be served by more than one D4Ag enterprise. However, this 'double counting' is likely small at the moment and concentrated in a few countries with high D4Ag activity, such as Kenya and Nigeria.
- 275 These findings are based on our comprehensive review of D4Ag solutions in the region. It is possible, however, that the two countries without D4Ag enterprises (e.g. Seychelles, Sao Tome and Principe, Mauritania, Equatorial Guinea, Eritrea, Djibouti) do have some presence of D4Ag solutions that we were not able to uncover during our study.
- 276 Taking a broader view, of the 390 solutions in our database, excluding non-revenue seeking MNO and agribusinesses solutions, commercial enterprises stood behind 74% of all solutions and an unknown share of the 15% of solutions that were backed by NGOs did have some earned revenues, so the number of revenue-seeking solutions in the broader D4Ag sector is likely over 80%.
- 277 We defined companies with a profitable and stable business model as those that claimed that their costs were less than 90% of their operating budgets and revenues were more than 90%. Please note that many enterprises claimed that their costs and revenues were both less than 90% of their operating budgets, in which case we could not determine their profitability and did not include them in this count.
- 278 For instance, AGRA examined the economics of 15 African D4Ag enterprises in depth and found that only a third had sustainable economics in the absence of substantial ongoing donor support. AGRA. 2016. 'Digital Harvest'. Enterprises in the AGRA sample were, however, more established than the average D4Ag solution in our survey.
- 279 Looking at this data in the broader start-up context, studies of new business starts in the US and Europe and oft-cited benchmarks from the tech VC industry suggest that 2-3 years are required, on average, for companies to reach profitability,



- with most companies starting to break even at some point in the second year and reaching steady profitability in the third. See, e.g., US Small Business Administration data on business starts in the US (www.sba.gov); see also Mansfield, M. 2019. 'Startup statistics: The numbers you need to know'.
- 280 Our interviews with VC experts for Africa suggest that a 20-30% share of profitable and/or sustainable enterprises is to be expected in a highly social sector of this type in Africa.
- 281 This rough projection applies the 26% share of profitable enterprises to the 289 commercial D4Ag solutions in the database, and then assumes a 50-75% failure rate for non-profitable solutions and 20-30% failure rate for profitable solutions over the next 3 years, not counting new business entry which is likely to be substantial and will feature some firm that break even early.
- 282 See note 284 for details based on self-reported revenue/user/year for solutions in our database which draws on both survey data and interviews with leading D4Ag solution providers. The ranges of self-reported per-farmer revenues are wide because each covers a broad variety of underlying business models. For instance, D4Ag market linkage players that use virtual buyer-seller marketplaces tend to earn a very small fee for matching supply with demand, often no more than a few Euros of value for the transaction. Whereas digitally-enabled value chain integrator types of market linkage models, such as those from Twiga, iProcure or Tulaa, can earn 10-20x this amount for their value chain intermediation services. For financial services, please note that these numbers do not include interest income as the focus of these benchmarks in our data was on D4Ag credit, insurance, and payment intermediaries rather than traditional FSPs who have digitised their value proposition.
- 283 The number of addressable farmers is likely different for each use case. For advisory services, we believe that it is possible for multiple members of a smallholder farmer household to be a user. As such, we have defined the addressable market as the total number of estimated smallholder farmers and pastoralists in Africa, i.e., ~250 million. For the other use cases, it is likely that these services are used at the level of the household (e.g., only one market linkage application or insurance or credit per smallholder farm), and as such we use 73 million as the total number of addressable farmers for these use cases. This is without a doubt a radical simplification of a complex reality, but likely does provide a directional sense for the market's size.
- 284 The range for total addressable market is quite high given the wide range of ARPU within and across use cases. We estimate that ARPU for advisory services is in the order of $\square 0.90$ - $\square 8.90$ per farmer/year, financial access services is $\square 0.40$ - $\square 6.70$ per farmer/year, market linkage between $\square 2.70$ - $\square 50$ per farmer/year, and supply chain management to be $\square 0.60$ - $\square 3.90$ per farmer/year. For financial access it is typical for payments, credit, and insurance products to be combined, so actual revenue for a fully integrated financial access player would be in the $\square 3$ - $\square 14$ range. These figures are based on self-reported figures from survey respondents and figures shared with us during interviews with implementers.
- 285 We assumed access to a mobile phone as an important constraint to smallholder farmer ability to use digital solutions. Access to a mobile phone could mean multiple things, however, so we looked at this figure in multiple ways. The most restrictive way to look at this figure is to assume that only individual unique mobile subscribers have access to a mobile phone. For this, we assumed a minimum of 39% of smallholder farmers (using GSMA's 2018 estimate of unique subscribers across Africa and applying a 1.3:1 urban to rural access ratio to account for the fact that rural penetration is lower than urban penetration). A second way of looking at this figure is to look at phone ownership data for individual smallholder farmer households. We estimate this to be 50-60% based on phone ownership to unique subscriber ratios from select countries (e.g., Nigeria) and smallholder household surveys. A third way of understanding household access to a mobile phone is to use smallholder farmer household ownership of a phone. Based on CGAP smallholder farmer level data from a handful of countries across Africa (and ratios of household phone ownership to unique subs and any phone ownership), we estimate this figure to be ~70% across the Sub-Saharan Africa region today. It is possible that smallholder farmers could theoretically access phones that are not in their household to use D4Ag solutions, but we did not include that here as we do not have reliable estimates, and it is likely that farmers need reliable, regular access to a phone to use solutions, which is much harder if the phone is not within the household. Therefore, for the purposes of our TAM calculation, we used a range of 39-70% to represent the likely minimum and maximum levels of connectivity among smallholder farmers. Another potential connectivity constraint is rural signal coverage, which we estimate at 70%+ in Sub-Saharan Africa today, so comparable to the household penetration of phones figure.
- 286 This estimate is calculated from known (self-reported) revenues of ~ $\square 07$ million from 76 enterprises in our database. To this we added estimated revenues for enterprises whose revenues were not already known. Where we knew the user base, but not revenues, we used average revenue per user estimates by primary use case. For solutions where we did not know the user figures, we applied the average user figure for deployments (removing big outliers) to estimate the number of users, along with the same average revenue per user (ARPU) estimates. The numbers are a conservative estimate. For instance, revenues of D4Ag data intermediaries (e.g., data analytics players, drone companies with agriculture projects) are not estimated with the exception of those that reveal this information publicly and where it is possible to identify the agriculture specific revenue streams. In the case of financial access solutions, we focus on digital intermediation revenues and product fees (e.g., farmer credit scoring revenues) but not interest income on farmer loans.
- 287 Penetration of addressable market derived by dividing the mid-point value for sector earned revenues (~ $\square 27$ million) by the average TAM in conservative ($\square 1.6$ billion) and less conservative ($\square 2.9$ billion) scenarios, which yields a penetration of 4-8%, or 6% on average.
- 288 There are insufficient data to make impact comparisons for the other D4Ag use cases.
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- 300 Ibid. Advisory services and financial access are not the only use cases that can support climate resilience. For example, market linkage solutions could provide farmers access to new types of fertilisers with more or less nitrogen as soil contents alter in response to changing climate. See CGIAR. 2013. 'Climate-smart Villages – a community approach to sustainable agricultural development' (www.cgspace.cgiar.org/bitstream/handle/10568/33322/CCAFSClimate-SmartVillages2013.pdf).
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Chapter 4

- 311 As explained in more detail later in Chapter 4, the high end of the range in this estimate is based on a 44% annual growth rate for registered farmers and revenues (based on the last 3 year trend). The low end of the range, shows a growth rate that is half this rate (22%), which is what would happen if the number of farmers added over next 3 years (in absolute terms) was identical to the number added in the past 3 years (i.e., same pace of farmer acquisition due to challenges in moving into new and more difficult markets)."
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- 313 Chapter 2 and 3 delved into some of the challenges of 'pure-play' information and advisory service D4Ag business models. For more on these issues for early generation advisory solutions like Esoko, see e.g., Miller-Wise, H. 2017. 'Why we broke up the company: a former CEO of mAgri pioneer Esoko speaks.' *Next Billion* (<https://nextbillion.net/why-we-broke-up-the-company-a-former-ceo-of-m-agri-pioneer-esoko-explains/>). See also the related and highly informative sector actor discussion thread in <https://www.ictworks.org/esoko-agricultural-market-prices-failures/#.XPPKFogzY2x>.
- 314 See, e.g., Syngenta Foundation's perspective that "a broad, holistic approach needs to be taken to drive greater value and impact for smallholder farmers" while at the same time improving the commercial viability of D4Ag models. SFSA (2019).
- 315 See impact discussion of bundled solutions in Chapter 3.
- 316 Analysis of the CTA-Dalberg database suggests that at least 25% and perhaps as many as 35% of D4Ag advisory and market linkage solutions, for instance, feature agents as part of the model directly or indirectly.
- 317 SFSA 2019.
- 318 For more formal value chains, D4Ag supply chain management solutions, for instance, are already inherently agent-based models as they help agribusiness interact with the agents and farmers in their value chains.
- 319 Our interviews suggest, for instance, that the incremental costs of integrating agents are likely to sit in the range of an incremental $\square 0.3$ -1.8 per farmer per month (assuming fixed agent compensation of $\square 90$ -270 per month, a realistic range for much of Africa, and agent to farmer ratios of 1:150 to 1:300). This sum of $\square 7$ -21 incremental costs per farmer per year is a meaningful amount for most African smallholders, but is not prohibitive if the increased costs can pay for themselves through improved D4Ag solution impacts. The threshold for this to break-even is not high, using average Sub-Saharan Africa farm monthly household income ranges of $\square 50$ -250, these numbers would mean that a farmer would need to see only a 0.5-3% improvement in incomes (or reduction in costs) to justify the economics of the agent model.
- 320 See the Taobao case study at the end of Chapter 2.
- 321 See, e.g., Better Than Cash Alliance. 2017. 'The Role of Digital Payments in Sustainable Agriculture and Food Security'.



- 322 GSMA estimated the total available for farmer B2P payment digitalisation at $\square 57$ billion ($\square 64$ billion) in Sub-Saharan Africa in 2020 and assumed 50 basis points (0.5%) revenues for digital payment providers, $\square 280$ million. GSMA. 2016. 'Market size and opportunity in digitising payments in agricultural value chains.' This number does not map neatly to Dalberg's total addressable market sizing for D4Ag due to methodological differences, but we likewise estimate the agriculture payment digitalisation opportunity in Africa to be in the hundreds of millions ($> \square 500$ millions) in 2019, though much of this revenue potential is only available for digital payment backbone providers rather than D4Ag intermediaries linking farmers to payments (i.e., only taking a share of the 50 basis points of revenue for their services).
- 323 Ibid.
- 324 Better Than Cash Alliance. 2017. 'How Digitizing Agricultural Input Payments in Rural Kenya Is Tackling Poverty: The Case of One Acre Fund'.
- 325 It is also important to note the underlying location-based technologies that enable many of these advanced technologies to function, and how they have improved in recent years.
- 326 Twenty-eight per cent of respondents answered IoT, 32% answered blockchain, and 20% answered machine learning.
- 327 This discussion draws heavily on USAID's recent report on agriculture data for smallholder farmers. See USAID. 2018. 'Digital Farmer Profiles: Reimagining Smallholder Agriculture' (www.usaid.gov/sites/default/files/documents/15396/Data_Driven_Agriculture_Farmer_Profile.pdf).
- 328 Ibid.
- 329 Ibid.
- 330 Climate Focus and USAID. 2018. 'Policy Brief – ICT Solutions for Inclusive Agricultural Value Chains' (www.agrilinks.org/sites/default/files/brief_5_-_ict_solutions_for_agricultural_value_chains.pdf).
- 331 USAID, 2018. 'Digital Farmer Profiles: Reimagining Smallholder Agriculture' (www.usaid.gov/sites/default/files/documents/15396/Data_Driven_Agriculture_Farmer_Profile.pdf).
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- 333 CTA is undertaking a number of projects in Africa (including in Tanzania, Ghana, Swaziland and Benin) to survey, identify and demark plots of land. The Omidyar Network is similarly working in Ghana to help build capacity within the government to use drones for land tenure adjudication. A number of D4Ag enterprises have also deployed innovative solutions for these purposes on the ground. Meridia in Ghana (see <https://www.meridia.land/>) is one of the notable examples in this space.
- 334 Ibid.
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- 345 CGIAR Platform for Big Data website (www.bigdata.cgiar.org/about-the-platform/).
- 346 Protopop, I. and Shanoyan, A. 2016. 'Big Data and Smallholder Farmers: Big Data Applications in the Agri-Food Supply Chain in Developing Countries'. *The International Food and Agribusiness Management Review* (www.ifama.org/resources/Documents/v19ia/920150139.pdf).
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- 350 Ibid.; USAID, 2018. 'Digital Farmer Profiles: Reimagining Smallholder Agriculture' (www.usaid.gov/sites/default/files/documents/15396/Data_Driven_Agriculture_Farmer_Profile.pdf).
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- 357 Ibid.
- 358 As a directional order of magnitude, the ~390 D4Ag players focused on African smallholder agriculture are already absorbing a significant share of the ~€280 million of all grant, debt, and equity funding annually that was going into African D4Ag ecosystems (see analysis later in this chapter). The precise share of this amount that went to individual enterprises is unknown, as we do not know the volume of donors' public good D4Ag investments not specific to any individual enterprise. We also do not know what share of required D4Ag enterprise funding these investments satisfied, but we can project that if such funding was to grow at the pace of new solution starts or at the historical pace of farmer registrations (44-45% across both variables), the funding need would quickly approach €1 billion within 3 years or at the latest within 5 years if future sector growth was half of what had seen historically.
- 359 As a rough thought experiment, we have sized the amount of D4Ag public good investment into Ethiopia over the past few years including the EthioSIS soil information system investments, the livestock surveillance and pest and disease surveillance systems being put in place with the Bill and Melinda Gates Foundation's help, the government (ATA's) investment into farmer registration and the setup of the 80-28 national advisory infrastructure, and upcoming investments into digital finance, market linkage, and advisory platforms for the sector. The total amount of such investments across donors and the government totalled well over €50 million. Scaling this amount from Ethiopia to the entire Sub-Saharan Africa population suggests that the required level of D4Ag infrastructure investment is at least €500 million (scaled based on population size) and potentially as €1.2-2 billion (scaled assuming a fixed cost of €20-50 million per country).
- This number also does not include some critically important underlying infrastructure that is relevant for the agriculture sector, but is not agriculture-sector specific. The most notable example is weather (hydromet) infrastructure, where anecdotal interviews with Africa weather infrastructure experts suggest that the funding gap for Africa is in the high hundreds of millions or low billions of Euros. For instance, the World Bank has estimated a few years ago that hydro-meteorological service modernisation for just 15 countries in Africa will require \$600 (£34 million), perhaps €1.5+ billion if extrapolated to the continent overall. Of this amount, in 2018, the World Bank was tracking ~\$900 million (£800 million) of active or pipeline hydromet investment for Sub-Saharan Africa, a gap of many hundreds of millions of Euros. <https://www.gfdrr.org/en/africa-hydromet-program/about>.
- 360 Assuming, as a thought experiment that half to a third of donor funds in 2019 were allocated to D4Ag infrastructure (€33-80 million annually), this would mean a funding stream of €250-400 over 5 years compared to the estimated D4Ag funding need of 1.2-2 billion (excluding hydromet services), a resulting gap of perhaps 1-1.5 billion. These numbers are, of course, pure conjecture, but do point to the relative magnitudes of the sums involved.
- 361 Among others, this includes the African Development Bank, the Bill and Melinda Gates Foundation, the Department for International Development (DFID), the Dutch Foreign Ministry, Mastercard Foundation, Syngenta Foundation, USAID, and the World Bank.
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Chapter 5

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- 381 Malabo Montpellier Panel. 2019. 'Smart Value Chains: Policy Innovations for the Digitalisation of African Agriculture.' <https://www.mamopanel.org/resources/reports-and-briefings/>.

Chapter 6

There are no endnotes for this chapter.

Annex 1 – Country Case Studies

- 382 Findings in this section come primarily from stakeholder interviews, the majority of which were conducted in a two-week research trip to Addis Ababa, Ethiopia.
- 383 Rounded to the nearest million and based on the number of users of Ethiopia-headquartered solution providers. Because all of these firms operate only in Ethiopia and no foreign providers are present, this also describes the number of users in the country. This figure does not adjust for users who may use more than one solution.
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- 387 Because mobile money is controlled by the state, Ethiopia has been able to scale the number of users registered with the service more rapidly. However, adoption (that is, the proportion of registered users actually using these services) remains low.
- 388 Rounded to the nearest hundred thousand and based on the number of users of Ghana-headquartered solution providers, rather than on the number of any users in the country. This figure does not adjust for users who may use more than one solution.
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- 399 Private equity investors like CardinalStone and Sahel Capital are mobilising investments into agricultural processing projects like Crest Agro to leverage digital tools for the aggregation and collection of information from farmers supplying the processing plants. Sterling Bank, in collaboration with AFEX and Binkabi, has committed up to 10 billion Naira (~£24 million) to a blockchain-supported agricultural commodity trading platform. Around ten venture capital firms and incubators are exploring the potential of AgTech investments, with companies like Venture Garden Group looking to open a new £7.8 million fund in 2019 partially focusing on AgTech. Some of Nigeria's largest agribusinesses have also started to direct their attention towards digitalisation. Dangote is developing digital solutions to optimise the company's internal processes, collect and manage detailed data about their suppliers, and streamline their domestic supply chains of rice and sugar. Companies like Flourmill and Indorama are set to do the same.



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- 408 Rounded to the nearest hundred thousand and based on the number of users of Kenya-headquartered solution providers, rather than any users in country. This figure does not adjust for users who may use more than one solution.
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- 420 USAID and The World Economic Forum.
- 421 AfDB website (www.afdb.org/en/countries/east-africa/rwanda/rwanda-economic-outlook/).
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- 433 There are a number of challenges specific to the Sahel. Chief among these include: (i) governance and security challenges (e.g., rising insecurity, violent conflicts, cross-border threats), which are compounded by weak state institutions and inadequate provision of public services; (ii) development and humanitarian challenges (namely food insecurity, forced displacement, and vulnerability to external shocks). As an illustration, ~6.9 million people across the Sahel are currently experiencing a food crisis. These challenges are exacerbating security issues in the region; (iii) socio-economic challenges resulting from unemployment, inequality and lack of job opportunities. To face these challenges, the G5 Sahel group was created in December 2014 with its membership comprised of Burkina Faso, Chad, Mali, Mauritania and Niger.
- 434 Rounded to the nearest hundred thousand and based on the number of users of Nigeria-headquartered solution providers, rather than number of users of any D4Ag solutions in country. This figure does not adjust for users who may use more than one solution.



- 435 OECD.Stat website (www.stats.oecd.org/viewhtml.aspx?datasetcode=DACSECTOR&lang=en).
- 436 PIP G5 Sahel website (<https://www.conference-g5sahel.org/copie-de-apropos-g5>).
- 437 Mali, with mobile phone penetration above the Sub-Saharan Africa average, and Burkina Faso have strong digital foundations off of which to build attractive and widely-used D4Ag products. The resulting popularity of mobile money, even among rural populations, led MTN, Orange, and Airtel to launch cross-border money transfers between these two nations and several non-G5 neighbours in 2016. Chad and Niger, by contrast, exhibit mobile penetration rates towards the lowest end of the Sub-Saharan Africa spectrum. These countries have historically taxed MNOs at extraordinary rates (e.g., 50% in Chad as of 2014), discouraging investment and resulting in the second lowest and lowest scores in GSMA's Connectivity Index. Niger, however, has taken steps to increase its connectivity, granting Airtel a new license, reviewing its MNO tax system, funding its part of the Trans-Saharan Backbone network, and attracting Orange Bank's service to apply for licensing. As a result, Niger currently boasts the highest compound annual growth rate (CAGR) of unique mobile phone subscribers in Africa (6%). Mauritania, in contrast to the other four G5 nations, has a majority urban population, so its relatively high mobile penetration rate conceals exceedingly low coverage and poor service in rural areas – this contributes to dismal mobile money penetration despite decent phone penetration.
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- 441 SNV website (<http://www.snv.org/project/satellites-pastoralism-and-climate-change-stamp>).
- 442 An aggregator is an application, software, or organisation that gathers multiple sources of data or information, processes them (possibly), and redistributes them.

Annex 2

There are no endnotes for this annex.

Annex 3 – Detailed Methodology

- 443 See Lowder, S.K. *et al.* 2016. 'The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide'. *World Development* (www.sciencedirect.com/science/article/pii/S0305750X15002703); see also, a more detailed report estimating all farms in Sub-Saharan Africa at 77 million of which 82% are <2 hectares in Lowder, S.K. *et al.* 2016 'Transformation in the size and distribution of farmland operated by household and other farms in Sub-Saharan Africa', 2016 AAAE Fifth International Conference, available at <https://ageconsearch.umn.edu/record/246969/?ln=en>.
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