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Mapping Policies and Structures for Kenya's Preparedness for Digital Agriculture

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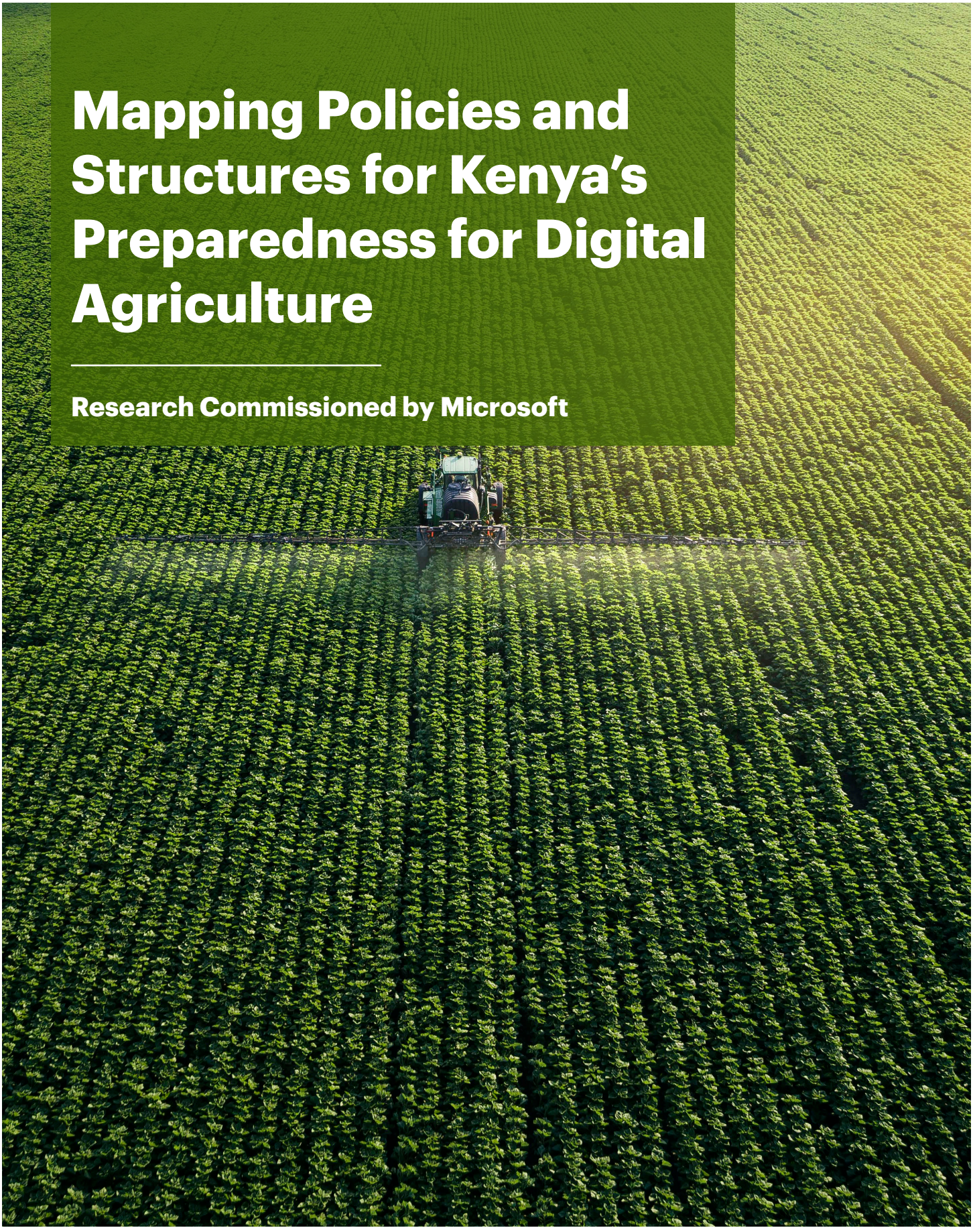

Table of Contents

Executive Summary

The objective of this paper is to improve the understanding and support the development of a regulatory and policy environment that can enable development of smart farming in Kenya and, by extension, Africa. Smart farming accentuates innovation and the utilisation of data, information technology and Artificial Intelligence (AI) in farming. This paper addresses two regulatory and policy based questions. First is 'what are the critical regulatory and policy frameworks that can drive digitisation and agricultural transformation in Kenya?' Second is 'what are the best policies that can enable Big Data and AI to drive agricultural transformation as envisioned by the government, thus enabling Kenya to utilise its limited agricultural resources more efficiently, become food-secure and build prosperous agribusiness sectors?' This paper addresses these questions and aims to prompt innovative regulatory and policy ideas, insights and knowledge that can provide the impetus for growth of digitisation of agriculture or smart farming in Kenya.

The opportunity for agricultural transformation in Kenya through digitisation is three-fold. First, this opportunity exists more broadly in agricultural production, supply chains improvements and value addition. It exists more specifically in the ability to improve efficiency and productivity amongst smallholder farmers. Agriculture is the biggest contributor to Kenya's Gross Domestic Product (GDP), export revenues and household income. However, millions of smallholder farmers dominate it. The practices of these farmers are primarily manual and labour-intensive. They are also over-reliant on outdated rain fed methods. As this paper will evidence, agriculture in Kenya is primarily carried out in smallholder farms, which constitute nearly a third of the country's arable land. Second, the opportunity for agricultural transformation in Kenya through digitisation can be found in the digital space that exists in Kenya. Kenya's population is digitally agile. Numerous innovations, high levels of internet connectivity and internet penetration that cover both urban and rural areas drive digitisation in Kenya. Third, the relatively friendly regulatory and policy environment that has enabled innovations enhances the opportunity for agricultural transformation in Kenya through digitisation. The fact that Kenya is well connected with numerous digital innovations and start-up companies reinforces this opportunity. Kenyans – including those in rural areas – are quick to adopt and use technology. The combination of a digitally agile population, extensive connectivity and internet penetration, and a friendly policy and regulatory environment have attracted local and international investments, start-up capital and big tech companies.

This paper will conclude by making policy recommendations on the best approaches for a digitised agricultural future for Kenya. The paper will advise that the Kenya Open Portal (KOD) provide the best platform for open access agriculture, digitisation, and smart farming in the country. The paper will recommend that for this to happen, there is need to establish critical protocols and structures for data collection. Additionally, all data collectors ought to be able to plug into KOD. This recommendation, if implemented, will not only make data publicly accessible, it will also ensure consistency in methodologies for data collection, and enhance the integrity of the data collected. This recommendation will be tempered by a recommendation for a farmer-private sector-civil society driven data platform, which is equally open and accessible to farmers and other relevant stakeholders. The paper, through appendix 1, makes the recommendation for how this would be modelled.

Acronyms

ACFTA Africa Continental Free Trade Area
AI Artificial Intelligence
AIA Access to Information Act
ASAL Arid and Semi-Arid Land
ASDS Agricultural Sector Development Strategy
ASTGS Agricultural Sector Transformation and Growth Strategy
ATP Agricultural Technology Providers
AU African Union
CA Communication Authority of Kenya
COMESA Common Market for Eastern and Southern Africa
CSO Civil Society Organisations
CTA Technical Centre for Agriculture and Rural Cooperation
DPA Data Privacy Act
EAC East African Community
EU European Union
FAO Food and Agriculture Organisation of the United Nations
FEWSN Famine Early Warning Systems Network
GDP Gross Domestic Product
GDPR General Data Protection Regulation
GFSI Global Food Security Index
GNP Gross National Product
GODAN Global Open Data for Agriculture and Nutrition
GoK Government of Kenya
GPS Global Positioning System
IBM Inclusive Business Models
ICTA Information, Communications and Technology Authority
IoFF Internet of Food and Farm
IoT Internet of Things
KALRO Kenya Agriculture and Livestock Research Organisation
KCSAP Kenya Climate Smart Agriculture Project
KODI Kenya Open Data Initiative
KOD Kenya Open Data
MoALF Ministry of Agriculture, Livestock and Fisheries
NAIP National Agriculture Investment Plan
NBS National Broadband Strategy
NDMA National Drought Management Authority
NGO Non-Governmental Organisation
OGL Open Government Licenses
PII Personally Identifiable Information
UAV Unmanned Aerial Vehicles
WB World Bank
WFP United Nations World Food Program

1.

Overview of Agricultural Digitisation and Smart Farming

Digitisation can help transform Kenya's agricultural sector, improve productivity, and help the country make significant progress towards achieving food security. For agricultural digitisation to be achieved there is a need to ensure the collection of farms data, and make these publicly accessible. However, critical policy and regulatory challenges around data governance can imped this process. To understand – and critically address – the policy challenges tied to the collection of agricultural data and smart farming, there is a need to first identify the potential policy and regulatory impediments.

Millions of smallholder farmers dominate Kenya's agricultural sector. However, they have minimal data available on their farming methods as well as the farm inputs and outputs. This can be overcome by setting up a system for farm data collection that is publicly accessible. For this to happen, there is a need to have a set of regulations and policies in place to support data collection and maintain the public availability and accessibility of data. At the same time, there is a need to protect the privacy of farmers whose data is being collected. How to make this happen is the challenge that needs to be addressed.

This paper provides a context that may improve the understanding of agricultural practices in Kenya and the significance of the agricultural sector to Kenya's economy. The paper outlines the challenges around the governance of the agricultural sector. Also, it looks into how the sector can evolve from its current mode to the digitisation of farming systems and methods. With this understanding and by considering the challenges therein, the paper identifies the opportunities for the digitisation of agriculture. It provides the justifications for digitising and proposes how to achieve this. Furthermore, the paper addresses the critical regulatory and policy issues around farm data collection and governance. It then goes ahead to make appropriate policy recommendations that can help Kenya achieve agricultural transformation through the digitisation of farming.

The transformation of smallholder farming to improve efficiency, productivity and assure quality controls enabled through digitisation can certainly support Kenya's agricultural transformation strategy. It can transform the use of more than four million hectares of farmed land as well as the livelihoods of more than five million rural households. Nevertheless, to enable agricultural transformation through digitisation, a large amount of data must be collected and properly utilised. This raises the question of how to collect the data; who collects and owns them; and how the data is stored, governed and used. This paper responds to these questions through the structure outlined below.

This introductory section – the first section of this paper – provides a brief outline of the objectives and the key issues that subsequent sections address in depth. The section lays out the structure of the paper, which sets out how the remaining sections of the paper deal with the issues at hand.

The second section is context setting. It provides an explanation of what digitisation in farming means, a definition of smart farming and how these can improve farm productivity. This section furthermore provides the background to and context of Kenya's agricultural sector and the food security situation. The ultimate aim of this section is to provide justifications that may help improve agricultural productivity through digitisation.
The third section of the paper builds on the context and justifications that the second section provides. It outlines the government's response through the Agricultural Sector Transformation and Growth Strategy (ASTGS). Particularly, this section outlines Kenya's national agricultural development and transformation agenda and how this places digitisation of agriculture at the centre of agricultural transformation strategy. Further, this third section of the paper identifies the opportunities for improvement in productivity, supply chain management and agricultural produce

value addition that the digitisation policies, if implemented, can achieve.

The fourth section of this paper makes the case for the transformation of agriculture through digitisation in Kenya. It does this by outlining the benefits that digitisation would bring to farmers and rural households as well as agricultural sector suppliers and input producers. This fourth section proceeds to address how digitising agriculture can help smallholder farmers accrue benefits from increased access to financial services providers, for example increase access to savings and credit facilities. These benefits are primarily through improving access to finance and credit for smallholder farmers. This fourth section of the paper addresses also how, overall, the accrued benefits align with the Government of Kenya's (GoK) ASTGS and its objectives of making Kenya food secure.

The fifth section of this paper focuses on the infrastructure required for a successful digital transformation of agriculture in Kenya. This entails an outline of the requisite digital skills, and a physical infrastructure that is required for a nationwide agricultural digitisation process. It also entails an outline of how Kenyans, particularly those in rural areas, access the internet. This section demonstrates also how mobile phone coverage, usage and technology can advance opportunities for the agricultural digitisation process in Kenya.

The sixth section is specifically concentrated on open data and data governance policy frameworks, with respect to agricultural data. It examines how agricultural data is currently collected vis-à-vis how it should be collected. For this, the section outlines and analyses the data governance and management policies that impact the collection, public availability, and usage of agricultural data. Then, the section assesses the effectiveness of these policies and, particularly, it looks into how they can either improve or impede digitisation of agriculture.

The sixth section concludes the paper. It provides policy recommendations in support of developing an effective framework for on-farm data collection and data governance in a bid to support the GoK's objective of agricultural transformation through digitisation. It recommends the Kenya Open Data (KOD) platform as the best option for an open access data framework for agriculture and provides a model through which this can be done. This section of the paper makes a further recommendation. It recommends a pilot of a non-government driven public platform and explores how such a pilot could provide the bedrock on which the dozens of non-governmental organisations currently engage with Kenyan farmers to share data. This further recommendation can provide a basis for modelling a publicly-driven agricultural data approach that compliments – and reinforces – the government's approaches through the ASTGS.

2.

Introduction and Overview of Kenya's Agriculture Sector

Digitisation of agriculture implies the application of digital technologies, innovations, and data to transform agri-business processes, models, and practices across the full spectrum of agricultural value chains. Robin Lougee (IBM Research Lead for Consumer Products and Agriculture) and Julian Ramiez-Villegas (Decision and Policy Analyst for the International Centre for Tropical Agriculture) conceptualise data-driven farming as the use of agricultural and climate data collected from a multiplicity of sources to produce more from less – less fertiliser, less water, and less land. (Lougee and Ramirez-Villegas 2018).

Data-driven farming thus entails enhancing the decision-making process of crop production by availing timely and robust data to provide insight in what, where and when to plant. It implies the use of digital technologies, innovations and data to transform the full spectrum of agricultural value chains. According to the Technical Centre for Agriculture and Rural Cooperation ACP-EU (CTA), this encompasses, "inter alia, productivity, post-harvest handling, market access, finance, and supply chain management. The aim is to achieve greater income for smallholder farmers, improve food and nutrition security, build climate resilience, and expand the inclusion of youth and women" (Tsan, et al. 2019).

Digitisation of agriculture, or "Smart Farming", accentuates innovation and the use of data, information and technology, and AI in farming. The Food and Agriculture Organization of the United Nations (FAO) defines smart farming as a "farming management concept using modern technology to increase the quantity and quality of agricultural products."[1] According to FAO, smart farming entails applications that increase access to Global Positioning System (GPS) soil scanning data, Internet of Things (IoT) and AI innovations for farmers. Smart farming can therefore enable farmers to increase significantly "the effectiveness of pesticides and fertilisers and use them more selectively". It can enable farmers to use also smart farming techniques in order to "better monitor the needs of individual animals and adjust their nutrition correspondingly, thereby preventing diseases and enhancing herd health."[2]

In smart farming, data-driven approaches to agriculture leverage digital farming and data analytics to improve the precision of agricultural decision-making relating to the maximisation of available resources. Such leveraging helps improve also productivity and strengthen supply chains and value addition opportunities. The data-driven approaches have become more viable due to the proliferation of data collection and processing capabilities at all levels of the agricultural value chains and the increased access to technology and internet connectivity in rural farming communities. These approaches have also become much more necessary as population growth continues amidst the ongoing wave of urbanisation, increased prosperity, greater commitment to holistic human development, and mounting pressure to buffer coming generations from the effects of climate change in Kenya.

[1] FAO, 'Farming Knowledge Platform' -<http://www.fao.org/family-farming/detail/en/c/897026/ > on 21 November 2020.

[2] FAO, 'Farming Knowledge Platform' -<http://www.fao.org/family-farming/detail/en/c/897026/ > on 21 November 2020.

2.1 An Overview of Kenya's Agriculture Sector and its Economic Significance

The importance of agriculture to Kenya is underlined by the fact that it is both the largest contributor to the Gross Domestic Product (GDP) and the main source of livelihood for most households. Agriculture contributes 27 percent of the GDP and provides employment – both formally and informally – to 40 percent of Kenyans, including nearly 70 percent of the rural population. In addition, the sector accounts for 65 percent of Kenya's export earnings (Wankuru et al, 2019; FAO, 2020).[3] Despite its significance to the economy and to livelihoods, numerous governance and practice challenges plague the Kenya's agricultural sector. Multiple actors – both public and private – make up the governance structure of agriculture in Kenya. These factors include the Ministry of Agriculture, Livestock and Fisheries (MoALF), a self-governing private sector,[4] and a range of parastatals and cooperatives as well as county governments. There are some large commercial farms that use technology in their operations. Nevertheless, common farming practice in Kenya is manual in smallholder farms devoid of technology and relying on dated rain fed agriculture methods. An estimated 4.5 million Kenyan households are small-scale farmers (ASTGS). Data from ASTGS and FAO indicate that average sizes of smallholder farms in Kenya range from 0.47 to 5.0 hectares.[5]

Category	Small-scale	Mid-size	Large-scale
Size of farm	0.5-5 ha	5-100 ha	100 ha
Shares of farms in Kenya	~66%	~20%	~14%
%marketed agricultural produce	~65%	5%	~30%

Figure 1: Thresholds for farm sizes in Kenya as defined by ASTGS.[6]

There are roughly 4.5 million farmers in Kenya. They are broken down into 3.5 million crop farmers; 600,000 pastoralists; and 130,000 fisher folk. Large-scale farming is practised on farms; averaging 50 hectares for crops and 30,000 hectares for livestock; and accounting for the remaining 30 percent of marketed produce. Large-scale farms produce mainly commercial crops such as maize, wheat, and cash crops (D'Alessandro et al, 2015).

D'Alessandro (2015) noted that Kenya's smallholder farms account for an estimated two thirds of agricultural produce. Smallholder farms are concentrated in high production areas and are largely constituted by exclusively agricultural households. Despite their low levels of commercialisation, smallholder farms are crucial to the supply of staple foods in their locales through subsistence for agricultural households and sales of surplus crop in local markets. Production on smallholder farms is predominantly reliant on rain fed systems, with only an estimated 7 percent being irrigated. This is despite the fact that83 percent of Kenya being arid or semiarid land (ASAL) generally unsuitable for rain fed systems.

[3] Peter Chacha Wankuru, Allen Curtis Dennis, Umutesi Angelique, Patrick Nediru Chege, Celina Katunda Mutie, Sarah Oludamilola Sanya, Ladisy Komba Chengula, Tim Njagi, Utz Johann, Alastair Peter Francis Haynes, 'Kenya economic update: Unbundling the slack in private sector investment – Transforming agriculture sector productivity and linkages to poverty reduction', 2019 (Hereafter as Wankuru et al.). See also FAO, 'Kenya at a glance', <http://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/> on 10 June 2020 (hereafter as FAO, 2020).

[4] The Fresh Produce Exporters Association of Kenya is a good example of private sector governing itself.

[5] George Rapsomanikis, 'The economic lives of smallholder farmers: An analysis based on household data from nine countries', FAO, 2015, 5.

[6] **Figure 1:** Thresholds for farm size as defined by ASGTS. Source: 'Agricultural growth and transformation strategy: Towards sustainable agricultural transformation and food security in Kenya', 2019-2029.

2.1 An Overview of Kenya's Agriculture Sector and its Economic Significance (continued)

Compared to its neighbours, Kenya currently has the lowest share of Agri-exports per capita - at 16 percent. This compares with 27 percent in Tanzania and 34 percent in Uganda.[7] There is a significant opportunity for Kenya to boost these ratios, both for small-scale and large-scale producers in crops (e.g. Processing imported wheat into pasta). There is also a significant opportunity for Kenya to boost livestock (e.g. dried beef). There also exists a variety of opportunities for Kenya in the fisheries value chain, which the Draft Agricultural Policy (2016) provides for. These opportunities include fish filleting, canning, smoking and other by-products.

Approximately three in four Kenyans live in rural areas and depend on agriculture as their principal source of income. On ASAL, the livestock subsector accounts for nearly 90 percent of agricultural employment. Household incomes with crop farming making up the difference. With so many Kenyans involved in agriculture, growth in the sector has considerable potential to raise living standards, particularly in rural agricultural areas. Between 2005/2006 and 2015/2016, poverty in Kenya declined from 46.6 percent to 36.1 percent. While urban poverty rates in Kenya decreased by only 2.7 percent, from 32.1 percent to 29.4 percent, rural poverty rates decreased from 50.5 percent to 38.8 percent. Income growth in exclusively agricultural households accounted for 31.4 percent of the reduction in rural poverty. The productivity of Kenya's agricultural sector is therefore understandably linked to national GDP performance and economic growth. Figure 1 below illustrates the correlation of agricultural GDP growth and national GDP growth between 2000 and 2018.[8]

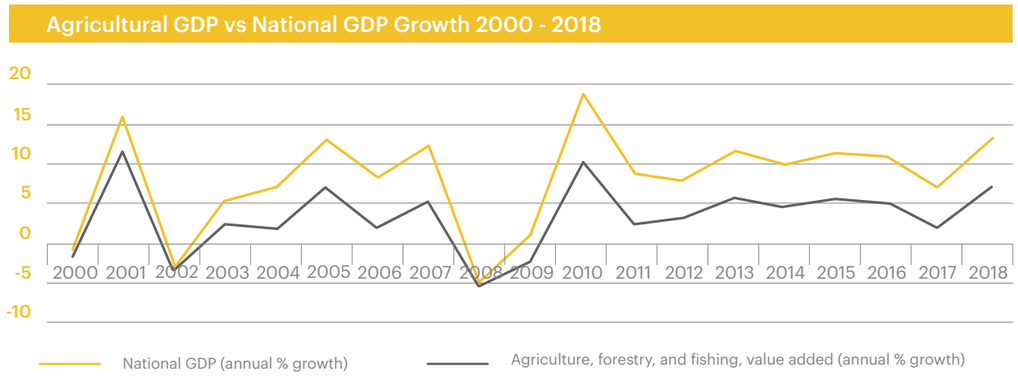

Figure 2: Agricultural Growth GDP vs National Growth GDP[9]

2.2 Food Security Challenges

Food security is a considerable humanitarian challenge in Kenya. Roughly, 1.5 million Kenyans are chronically food-insecure, with 1.3 million in ASALs alone. The number rises to between 3.4 and 3.7 million Kenyans during emergencies such as droughts (GoK, 2019). In 2016, the United Nations World Food Programme (WFP) noted that Kenya is a food-deficit country. It is "vulnerable to international price fluctuations as well as to trade barriers sometimes imposed by neighbouring countries from which it

[7] Agriculture GDP growth vs National GDP Growth in Kenya 2000 – 2018. Source: World Bank World Development Indicators, -<https://databank.worldbank.org/source/world-development-indicators> on 18 November 2020.

[8] Agriculture GDP growth vs National GDP Growth in Kenya 2000 – 2018. Source: World Bank World Development Indicators, -<https://databank.worldbank.org/source/world-development-indicators> on 18 November 2020.

[9] **Figure 2:** Agriculture GDP growth vs National GDP Growth in Kenya 2000 – 2018. Source: World Bank World Development Indicators -<https://databank.worldbank.org/source/world-development-indicators> on 18 November 2020.

2.2 Food Security Challenges (continued)

imports."[10] Three years later, in 2019, the WFP was of the view that, although 88 percent of Kenyans have acceptable food consumption, an estimated 4 million (12 percent) of the population are food-insecure.

The same year, the Global Food Security Index (GFSI), which scores a nation's food security by considering the affordability, availability, and quality and safety of food for the average person in that country, ranked Kenya 84th out of 113 countries with an overall score of 50.7 percent. GFSI also measures the stability of natural resources relevant to food production in terms of exposure to climate change, natural resource risks, and the country's capacity to respond effectively to natural resource risks. Kenya's GFSI ranking places it at 11th in Africa overall, and 8th in Sub-Saharan Africa. At 48th globally, South Africa ranked first in Africa with a score of 67.3 percent. The GFSI gave Kenya only moderate performance in resilience to depletion of natural assets necessary to support food security.[11]

Smallholder farmers, who principally employ rain fed systems, produce 63 percent of Kenya's food. The result is a near-overall economic dominance by smallholder farms in rural areas. High dependencies on subsistence farming (with less than a quarter of farm produce sold) and low connectivity to supply chains from the rest of the country characterize this economic dominance (FAO, 2015). The overreliance on rain fed crop cultivation poses a formidable challenge to agricultural productivity as both Kenya's economic backbone and main guarantor of food security. Area expansion mainly drives growth in agricultural GDP. Yet most of Kenya's land area is ASAL, offering little prospects for the development of rain fed crop cultivation (Boulanger, et al. 2018).

The two main determinants of the availability of agricultural products are environmental conditions (e.g. available land, climate, pests, soil, and water) and crop management decisions that farmers take (FAO 2019). Kenyan smallholder farms have limited capacity to expand into other areas (e.g. mechanisation). This is due to limited capital and water resource scarcity challenges, which constrict agricultural development in ASALs. This places a premium on management approaches to improving productivity in areas suitable for rain fed systems to strengthen Kenya's agricultural sector and food security situation.

At the same time, agricultural activities that can be conducted in ASAL areas — be they irrigated farms or livestock rearing — are an unignorable complement. They afford the opportunity to explore the maximisation of specialised agricultural production across a wider array of agricultural value chains. Kenya's development priorities in agriculture certainly call for a more holistic mode of developing the nation's agricultural sector. This would help maximise the equitable distribution of value, avail a varied food basket to Kenyans, and ensure the stability of the agricultural sector and overall food security. The staple foods in Kenya are maize, wheat, Irish potatoes, and dry beans, and increasingly rice. Underlying the importance of smallholder farmers to Kenya's food security, D'Alessandro et al, observe that 3 million smallholder farmers account for 70 percent of maize yields – between 37 and 40 million bags annually. The main horticultural crops in Kenya are vegetables, fruits, flowers, nuts and herbs and spices as well as cut flowers (D'Alessandro et al, 2015).

This section of the paper has provided a definition of agricultural digitisation and how it enables smart farming. The section has given an overview of Kenya's agricultural sector and illustrated the significance of this sector to Kenya's GDP. More importantly, it has demonstrated how a large number of Kenya's population – particularly the rural population – is dependent on agriculture for their livelihoods. It has also demonstrated the scope for agriculture to alleviate rural household poverty. Further, the section has underlined Kenya's food-security challenges, showing Kenya's ranking in global food security indices. The content of this section is therefore useful in informing the flow of the conversation throughout this paper. Taken as a whole, this section has set the context for section three. Section three deals with GoK agricultural transformation agenda and the role that digitisation and data can play in this agenda.

[10] United Nations World Food Program, Comprehensive food security and vulnerability survey: Summary report Kenya, WFP, 2016.

[11] GFSI, (2019) <https://foodsecurityindex.eiu.com/Country/Details#Kenya> on 18 November 2020.

3.

Kenya's National Agricultural Development Agenda and Opportunities through Digitisation

The Agriculture Sector Growth and Transformation Strategy (ASTGS) prioritises food security, sector productivity and digitisation to drive transformation of agriculture in Kenya. Agricultural policies in Kenya have historically prioritised increasing productivity and income growth. This has served as the launching pad for policies that aim at stabilising, commercialising and intensifying agricultural production as well as promoting participatory policy formulation and environmental sustainability (Boulanger, et al. 2018).

The Vision 2030[12] road map for Kenya's economic and social development aims at transforming Kenya into "a newly industrialised, middle-income country providing a high quality of life to all its citizens in a clean and secure environment." It identifies agriculture as a key development sector on the road to the envisaged 10 percent annual national economic growth rate. A key aspiration, recognising the centrality of smallholder farming to Kenya's economic stability, is the transformation of smallholder agriculture from subsistence to innovative and commercially oriented enterprises through digital technologies and innovations – smart farming. As previously stated, more than four million smallholder farmers account for two thirds of agricultural output through manual and dated farming practises on an estimated seven million hectares. With more than two thirds of Kenya's arable land being under smallholder farming, there is an enormous opportunity for massive expansion and improvement of agricultural outputs through technology-driven smart farming.[13]

The Agriculture Sector Development Strategy (ASDS) 2010-2029 was adopted as policy by the GoK to operationalise Vision 2030 plans for agriculture and was the precursor to the ASTGS. The ASTGS builds on the ASDS. The objectives of the ASTGS are to resolve four major challenges for Kenyan agriculture (Baliéand, et al. 2019):

- The endemic low productivity due to policy and structural constraints;
- Sub-optimal land use with consequent pressure on land resources as the population grows;
- Inefficient markets due to insufficient storage capacity and poor access to input or output markets; and
- Low levels of value addition and largely informal value chains, especially for agricultural exports in the tea, coffee and flower sectors.

The ASDS had set out strategic objectives for each agriculture subsector (crops and land, livestock, fisheries, and cooperatives), and listed six major intervention areas; namely, irrigation and water management, land use, development of Northern Kenya, natural resource management, development of river basins, and forestry and wildlife. However, soon after the development of the ASDS, the Constitution of Kenya 2010 came into effect. The ASDS had no consideration for the newly devolved governance structure under the Constitution of 2010, with agriculture becoming a devolved funciton. There was, therefore, the need to revise Kenya's agricultural policy. Consequently, the ASTGS and a new National Agricultural Investment Plan (NAIP) were adopted as policies by GoK for the period spanning 2018-2030 (Baliéand, et al. 2019). The ASTGS prioritises three anchors to drive the 10-year transformation plan, with specific targets set for the first five years. These

[12] A national long-term development blueprint to create a globally competitive and prosperous nation with a high quality of life by 2030 that aims to transform Kenya into a newly industrializing, middle-income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment.

[13] Stephen P. D'Alessandro, Jorge Caballero, John Lichte & Simon Simpkin, 'Kenya: Agricultural sector risk assessment', Word Bank Group, 2015.

anchors purpose to increase small-scale agricultural incomes,[14] agricultural output and value addition,[15] and household food resilience. Key to the ASTGS is its identification of three enablers that are central to sustaining the value that these anchors are intended to unlock. These are:

- Building knowledge and skills that are focused on technical and management skills in the field;
- Strengthening research and innovation, and launching digital and data use cases for better decision-making and performance management; and
- Sustainability and crisis management.

Of these three enablers, the second is particularly compelling. This is due to the multiplier effect that digitisation and data analytics can introduce to the agricultural sector. Kenya is relatively advanced in terms of digital literacy and uptake in Africa. It is also well placed to lead the continent's digital embrace as trading commences under the East African Community (EAC), Common Market for Eastern and Southern Africa (COMESA), and the African Continental Free Trade Area (AfCFTA). There is a multiplicity of data handlers. They are both in public and private sectors. They collect data that are relevant to agricultural production and value chains. These handlers, particularly those involved in the agriculture sector as well as Kenya's digital skills infrastructure and capacity, are expanded on in sections 3 and 4.

A national focus on research and innovation around digital and data-driven farming is necessary to integrate the decentralised operations of Kenyan data handlers into a coherent framework, which may facilitate data exchanges and wide-scale analytics. This holds enormous promise for improving the scale and utility of agriculture performance assessments. Crucially, it holds enormous promise for establishing a base for rapid concurrent innovations, which may augment productivity across multiple areas in Kenya's agricultural sector. Thus, pragmatic considerations on use cases for the digitisation of agriculture need to shape data-driven progress in Kenya's agriculture policy aspirations. The opportunity for data to transform value chains means that such aspirations must be actioned with due consideration of data subjects and users' rights. This is discussed in section 5 of this paper.

3.1 Opportunities in Agricultural Data Creation, Collection, Aggregation and Use in Kenya

Access to digital technology can offer significant advantages across all of Kenya's agricultural value chains. This is by enabling new levels of interactivity between sector participants (GoK, 2019). The collection and use of data to inform decision-making can improve crop cycle timings, decrease uncertainties for investors, and lower the cost of identifying opportunities for improved efficiency.

Beneficiary	Benefits of Digitisation of the Agriculture Sector in Kenya
Smallholder Farmers	Greater productivity via the dissemination of agricultural advice and real-time information, and improved linkages to quality agricultural input and reliable off-take markets. For example, agriculture extension officers at the county (local) levels can provide smallholder farmers with more reliable information that improves productivity, understanding of standards and markets as well as access to markets.
	Increased farmer incomes as farmers produce in greater quantities, face lower crop losses, and access fairer input and off-take prices.
	Enhanced access to financing, particularly about multi-beneficiary investments targeted at blocks of agricultural data subjects (e.g. seed breeders and distributors).

[14] ASTGS aims to raise average annual small-scale farmer incomes by ~40% from KES 465/day to 625/day (USD3.96 to USD5.83 per day – exchange rates 24 August 2020).

[15] ASTGS aims to expand agricultural GDP (from KES 2.9 trillion to KES 3.9 trillion USD 27.07 billion – USD 36.4 billion – exchange rates 24t August 2020).

3.1 Opportunities in Agricultural Data Creation, Collection, Aggregation and Use in Kenya (continued)

Beneficiary	Benefits of Digitisation of the Agriculture Sector in Kenya
Smallholder Farmers	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.
	Improved growth and productivity of smallholder farms.
	Improved nutrition for smallholder farmer households as they consume food that is more nutritious.
	Greater participation of smallholder farmers in commercial value chains due to reduced transaction costs and risks.
	Better climate resilience through improved weather forecasts, advice on climate-smart agricultural practices, and improved access to weather-adaptation inputs.
Agro-dealers and Input Producers	Expanded reach to more farms enabling increased revenue opportunities
	A wider customer base facilitating cost-effective innovation and specialisation.
	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, therefore, input quality (e.g. through the widespread use of quality assurance and anti-counterfeiting tools to protect brand owners and farmers).
Financial Service Providers	Lower costs to identify, acquire and service smallholder farmers due to digital channels and tools that directly improve profitability and expand the catalogue of economically viable clients.
	Improved ability to assess, monitor and manage financial product risks via innovative digitised analytics of farmer profiles, digitised fields, weather, and remote sensing data.
	Lower risks of serving farmers due to digitally enabled delivery of better advice and market linkages.
Government	Improved information collation systems for the efficient and timely development, assessment, and revision of data-driven policies.
	Improved capacity to pre-empt, prevent, and respond to agricultural crisis risks at both the national and county levels.
	Improved macro-intelligence on agriculture sector trends and opportunities, which may allow for improved planning and resource-allocation around high promise areas.
	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. lower validation, implementation and administrative costs, less leakage from agricultural subsidies, more accountable and cost-efficient agronomy and extension).

3.1 Opportunities in Agricultural Data Creation, Collection, Aggregation and Use in Kenya (continued)

Kenya has certainly embarked on a process of digitising agriculture. However, multiple stakeholders collect and store many agricultural data in Kenya. These stakeholders include public sector institutions, private sector players and development partners. There is no platform for them to either interact or share information with each other, or exercise consistency in the methodology of collecting and using data. More than seven online government databases for agriculture exist. Examples are the Kenya Agriculture and Livestock Research Organisation (KALRO), the MoALF and the National Drought Management Authority (NDMA). Many of these databases have not been updated for several years. In addition, there are profiles of approximately 2 million farmers registered on the DigiFarm, MoA-Info and One Acre platforms.

Data on drought and early warning indicators can be found on the NDMA and Famine Early Warning Systems Network (FEWSN). Non-governmental organisations such as Solidaridad hold data of more than a million farmers. These data were collated to facilitate the development of socially responsible, ethically sound and profitable supply chains.

Kenya can, through the ASTGS, leverage the digitisation of the agriculture sector to enable improved data-driven agronomic solutions for production (crop yield, harvesting or preventing plant diseases) and supply and value chains (processing, value addition, transportation and marketing stages of agricultural practices). Data collection can be primarily done through:

- Global Satellite Systems – images and navigation;
- Advanced (remote) sensors;
- Robots and Unmanned Aerial Vehicles (UAVs) or drones;
- Agricultural machinery;
- Weather forecasting; and
- Qualitative/quantitative surveys.

The types of data that would be collected – including through surveys of farmers – would encompass:

- Farm data (from farms via sensors, machines or directly from farmers);
- Complementary data (such as weather, satellite and other environmental data, including precipitation events, evapotranspiration, and heat unit accumulation) ; and
- Proprietary data (data about agronomic inputs such as seeds or pesticides)

The decentralised nature of data management is not an issue per se. The challenge arises when the data cannot be seamlessly exchanged with authorised users for their access, with a guarantee that the data is of high quality and integrity. The lack of seamless mechanisms for sharing and exchange without authorisation further hamper the largely decentralised data. There is also a lack of safeguards that may guarantee the quality and integrity of the data. As noted in the ASTGS, the "current situation does not provide for a simple exchange of data. There is significant mistrust in data, duplication, wasted efforts, difficulty in scaling the data, and the inability to clearly identify the impact of certain interventions" (GoK 2019).

The Kenya Climate Smart Agriculture Project (KCSAP) funded by the World Bank evidences the government's efforts to address these issues/challenges. Through this, KALRO will set up and host a big data analytics platform that will provide agriculture insights through machine advanced analytics and data mining of datasets from various sources. This is intended to integrate agriculture datasets from public and research institutions into an open data platform. To ensure the success, viability and sustainability of this project, the challenges above must be addressed. The lack of a national data governance framework for agriculture and farmers can impede implementation.

This section has applied the FAO's definition of smart farming as the implementation of data and technology driven agriculture and outlined the significance of the agriculture sector to GDP. The section has demonstrated that smallholder famers dominate Kenya's agriculture sector. Nonetheless, the smallholder farmers engage in inefficient and dated farming practices. And, as a result of this, they have low outputs.

The opportunity for digital transformation of agriculture in Kenya certainly exists. As mentioned above, millions of smallholder farmers as well as the millions of hectares under smallholder farming make this opportunity possible. By leveraging digital technologies to support smallholder farmers improve productivity and improve access to agriculture supply chains and value addition, agricultural output in Kenya

3.1 Opportunities in Agricultural Data Creation, Collection, Aggregation and Use in Kenya (continued)

could be multiplied. The fact that Kenya is well connected with numerous digital innovations and start-up companies reinforces this opportunity. Kenyans, including those in rural areas, are quick to adopt and use technology. The transformation of smallholder farming to improve efficiency, productivity and assure quality controls enabled through digitisation can certainly support Kenya's agricultural transformation strategy. Therefore, this overview of the agriculture sector in Kenya provides the foundation for the next three sections.

4. Kenya's Digital Landscape and Digital Infrastructure

Amongst the developments cited in the preceding section as key opportunity factors in the digitisation of agriculture in Kenya is a technologically agile and adaptable population. This population are with well-developed digital skills, a fairly well-developed national internet and connectivity infrastructure with good national coverage, and a friendly policy framework that enables innovations to thrive. This section of the paper now delves deeper into digital the landscape in Kenya, demonstrating how it is conducive for smart farming.

According to the 2019 census, Kenya's population in 2019 was just slightly over 51 million, with urbanisation at 27 percent. This means that 73 percent of Kenya's population is rural. As already discussed in the preceding section, the rural population are largely smallholder farmers. The level of Internet connectivity in Kenya is high. At the end of 2019, there were 39.7 million active data subscriptions, 22.1 million of which were broadband (Communications Authority of Kenya 2019). A vast majority of these were mobile data subscriptions, which allow remote access on flexible payment plans (predominantly pay-as-you-go).

The national government continues to push for greater Internet access through broadband penetration. The government's National Broadband Strategy (NBS) 2018-2023, as communicated by the Communications Authority of Kenya (CA), envisions a "transformation of Kenya into a globally competitive knowledge-based society enabled by affordable, secure and fast broadband connectivity."[16] Through the NBS, the government aims to increase the fibre optic network from 9,000 miles to 50,000 miles. The NBS will also guarantee at least 3G broadband coverage to 94 percent of the population by the end of 2020.

Amongst the key objectives of the NBS is the development of e-agricultural systems for food and nutrition security (NBS, 2018). More specifically, the NBS strategy on agriculture envisages:

1. Improving supply chain efficiencies by leveraging the Internet to harmonise the demand and supply sides of the food value chain by linking areas of production to relevant markets;
2. Improving verification of quality; and
3. Applying technologies such as IoT and AI to improve farming and food production, of which the performance can be measured by the number of farmers, more specifically, smallholder farmers using technology in production processes as well as to access supply chain networks and markets (NBS, p. 27).

4.1 Mobile Phone and Money Services as Enablers for Digitisation Agriculture in Kenya

The ICT sector in Kenya continues to grow particularly through the uptake of mobile services. Mobile phone services play a critical role in the social and economic landscape in Kenya. As stated above, a vast majority of Kenyans use mobile phones for both voice communications and Internet access. According to the CA (2018), the number of mobile phone subscriptions in Kenya stood at just over 46 million in 2018 – about 90 percent of the population. This is one of the highest in Africa. 42 million of the mobile phone subscribers also had active data/Internet subscriptions (CA, 2018).[17] During the second quarter of the financial year 2019/20, the number of active mobile subscriptions in Kenya stood

[16] The National Broadband Strategy, 2018 – 2023.

[17] Communications Authority of Kenya, 'Sector statistics report,' 2018 – 2019.

4.1 Mobile Phone and Money Services as Enablers for Digitisation Agriculture in Kenya (continued)

at 54.5 million, which translates to a penetration rate of 114.8% for mobile subscriptions (CA, 2019).[18]

Mobile phone services and access in Kenya have led to significant innovations. Perhaps the most significant of these is MPesa. MPesa (hereafter referred to as mobile money) is a mobile money and digital payment service. It is a digital payments innovation developed by Kenya's largest communications company, Safaricom, in 2007. It is a form of electronic money transfer that was originally set up to enhance financial inclusion and to enable financial services to be extended to the unbanked segment of the population. This segment was primarily rural. Mobile money has been transformational in Kenya. Communication Authority of Kenya (CA) data (2018) indicated that Kenya had 29.8 million active mobile money subscribers in 2018. The value of mobile money transfers stood at KES 730 billion (approximately USD 6.8 billion), with the value of mobile money commerce transactions at KES 1.55 trillion (approximately USD 14.5 billion). Mobile money services in Kenya are fully integrated with banking services. This means that Kenyan banks have made it possible to transfer funds between bank and mobile money accounts within seconds. In addition, instant payments can be made from mobile money accounts directly to bank accounts and vice versa.

As previously stated, Kenya's population is largely rural, with livelihoods based on smallholder farming. The high level of mobile, internet services penetration and highly developed mobile money payment platforms portend great benefits for the agriculture sector. The impact of mobile services on smallholder farming populations is already evident. From an agricultural perspective, these factors can easily support the adoption of technology and growth of smart farming.

A study by Suri and Jack (2016) demonstrated the impact of mobile money. The study found that the combination of mobile services and mobile money reduced poverty in Kenya – lifting an estimated 2 percent of Kenyan households from extreme poverty. More significantly, for this study, mobile money has supported for example an estimated 185,000 women to graduate from subsistence farming into more entrepreneurial/business farming, while still operating out of their smallholder farms.[19] Internet penetration, mobile phone services and mobile money have reduced costs of inputs for smallholder farmers. Mobile money has enabled them to have direct contact with input suppliers as well as supply chains. Smallholder farmers can source and pay for their inputs without having to travel. Prior to this, Suri and Jack (2016) note that farmers had to travel long distances and bear expensive transactional costs associated with sending money. Mobile money has furthermore improved access to credit through dozens of micro-finance mobile lending platforms. Mobile services can cause significant benefits for rural households through improved access to information, lower marketing costs, and thus higher profits and incomes (Kikulwe, Fischer and Qaim 2014; Aker and Mbiti 2010). Additionally, mobile money services provide relatively secure opportunities for saving even in remote rural communities. This is instrumental to opening the formal economy and financial market to unbanked populations (Kikulwe, Fischer and Qaim 2014, Abraham 2007).

Mobile services present a great opportunity for alignment with and achieving the objectives of the ASTGS. This is premised on the high level of penetration, connectivity and use of mobile payment platforms as demonstrated in this section of the paper. However, there is still great scope for harnessing the mobile service advantages. Kenya has these advantages and they can support the digital transformation of agriculture in rural areas. This is through the Internet connectivity offered, digital payment systems and access to financial services. Mobile services can greatly improve the collection of data from millions of farmers across Kenya, thus enabling appropriate IoT applications to support smart farming.

[18] Mobile Penetration is computed by dividing the total number of mobile subscriptions (SIM cards) by the total population multiplied by 100. Communications Authority of Kenya, Second quarter sector statistics report for the financial year 2010/2020', October-December 2019.

[19] Tavneet Suri and William Jack, 'The long running poverty and gender impacts of mobile money, 354(6317)', Science, 2016.

5.

Frameworks for Open Data Governance

The preceding sections have defined data-driven agriculture and smart farming and provided an outline of the agriculture sector in Kenya and its significance to the economy. Section 1 outlined the types of data required to drive the digitisation of agriculture in Kenya. It has also examined the digital landscape and its suitability to drive the digitisation of agriculture. Sections two and three provided contexts to the agricultural sector in Kenya, the challenges of food security therein, and a rationalisation for the improving agriculture, particularly smallholder farming through digitisation.

The discussions of the digital landscape in Kenya in section five encompassed the digital tools most used particularly in farming communities demonstrates that there are some fundamentals in place to embark on the process of agricultural digitisation, and that this requires the relevant governance and policy framework to that can guide digitising of agriculture in Kneya. Consequently, it is necessary to discuss the data governance frameworks in Kenya, addressing their suitability to facilitate agricultural transformation through digitisation, and analyse the opportunities for improvements.

5.1 Open Data Access

Open data is "data that can be freely used, reused and redistributed by anyone, subject only, at most, to the requirement to attribute and share-alike" (Open Knowledge Foundation 2011). As a concept, 'openness' regarding data entails the advancement of a vigorous platform that anyone can access and use, and which prioritises sharing and interoperability of data. Open data is legally open. This means that it is available under an open license and is technically open. Put differently, it is available in a machine-readable and bulk form for no more than the cost of reproduction. Although there are many kinds of open data applications, typical requirements for work to be open are:

- Open license or status (the work is in the public domain or under an open license);
- The platform is accessible at no more than a reasonable one-time reproduction cost and downloadable via the Internet without charge;
- Machine-readable with individual elements that are easily accessible and modifiable; and
- An open format that can be fully processed with at least one free/libre/open-source software tool.

Several global institutions have advocated the need for open data access to enable data driven agriculture. The FAO has advocated for the creation of an enabling environment that supports open data access in agriculture. The Technical Centre for Agriculture and Rural Co-operation (CTA)[20] has also supported open access data in agriculture. According to the CTA, publicly available data, particularly through open government data platforms, can greatly enhance the digital transformation of agriculture and thus improve food security. For the Open Knowledge Foundation and the Global Open Data for Agriculture and Nutrition (GODAN), open data access for farmers and their service providers increase opportunities to "deliver meaningful knowledge to support them to take decisions that will improve their farm operations and make strategic decisions on investments." In line with these goals, the GoK's Open Data portal makes "public Government datasets accessible for free to the public in easy reusable formats" (Information, Communications and Technology Authority (ICTA). This portal by GoK can serve as the ideal platform for an agriculture database.

The community of international development partners and donors also recognises open data as having a key role in reducing inefficiencies and informational obstacles to the attainment of the Sustainable Development Goals (SDGs). The Nairobi Declaration on

[20] CTA,- <https://www.cta.int/en/digitalisation/article/shaping-agricultural-policy-and-outcomes-with-open-data-sid0419cec21-6af8-4025-80d5-1262ba5e0137> on 18 November 2020.

5.1 Open Data Access (continued)

Building Resilience on Food Security and Nutrition through Open Data (hereafter referred to as the "Nairobi Declaration") also recognises the critical role of open data in reducing inefficiencies. Through the Nairobi Declaration, fifteen African ministers responsible for agriculture attending the GODAN ministerial conference made commitments, inter alia, to make open data available as a means for assessing the implementation of the 2030 Agenda. These entailed, amongst other things, commitments to:

- Harnessing the power of new innovations, especially in the data revolution to solve the challenge of hunger; and
- Adopting the use and release of data for decision-making and action at all levels in agricultural value chains to increase productivity and achieve sustainable development and environmental protection in all its dimensions.

Open data applications in agriculture are frequently employed towards the attainment of SDG 2 (Zero Hunger). This is through approaches to improving agricultural productivity and introducing efficiencies in agricultural and nutritional value chains.

5.2 Kenya Open Data Framework, the Godan Initiative and Their Relevance to Agriculture

Open data is characterised by three factors; namely; open access, which means that everyone can obtain data without discriminatory access; database format, which means that data is accessible in bulk and within compatible sets of data; and freedom of reuse, which means that everyone can use, reuse, mix, or redistribute data without any undue obstacles.

In Kenya, Article 35 of the Constitution of Kenya establishes the regulatory framework for open access to data.[21] The Access to Information Act (AIA) operationalises Article 35. The objectives of the AIA include:

- Giving effect to the right of access to information by Kenyans;
- Providing a framework for the proactive disclosure and disclosure on request by public and private entities in Kenya; and
- Promoting routine and systematic information disclosure by public and private entities relating to accountability, transparency, public participation, and access to information.

In line with Article 35 and the AIA, and as a general indicator of GoK's utilitarian willingness to disseminate information and data widely, the GoK implemented the Kenya Open Data Initiative (KODI). KODI establishes the Kenya Open Data (KOD) portal. KOD makes government datasets available and accessible to the public at no cost and in reusable formats (ICTA).

From inception, the legal and policy development team for KODI was tasked by the GoK with developing an Open Data License that provided clear guidance regarding the use and reuse of data released under the initiative. After extensive consultations, the team agreed to adopt the UK's Open Government Licenses (OGL),[22] which in the UK had the effect of limiting the restrictive nature of Crown Copyright and enabling the free use and reuse of governmental data. [23] This movement toward general principles of access to open data is however set against a relief of the conventional limitations. Black letter law establish these limitations. It requires a proportionate counterbalancing between the public interest and the interests of third parties. These third parties may possess oversight authority

[21] Article 35, Constitution of Kenya (2010):
(1) Every citizen has the right of access to-
(a) Information held by the State; and
(b) Information held by another person and required for the exercise or protection of any right or fundamental freedom
(2) Every person has the right to the correction or deletion of untrue or misleading information that affects that person
(3) The State shall publish and publicize any important information affecting the nation.

[22] The National Archives, 'Open government license' -<https://www.nationalarchives.gov.uk/information-management/re-using-public-sector-information/uk-government-licensing-framework/open-government-licence/> on 16 July 2020.

[23] The National Archives' UK government licensing framework' -<https://www.nationalarchives.gov.uk/information-management/re-using-public-sector-information/uk-government-licensing-framework/> on 16 July 2020.

5.2 Kenya Open Data Framework, the Godan Initiative and Their Relevance to Agriculture (continued)

over the ownership of intellectual property[24] and the protection of privacy.[25] Further, the state may also assert legitimate concerns of national security.[26]

In furtherance of this policy signalling toward data openness by GoK, flagship 8 of the ASTGS identified the need to launch priority digital and data use cases to better drive decision-making and performance management in Kenya's agricultural sector. GODAN was a key partner in organising the meeting that led to the ministerial Nairobi Declaration. GODAN supports the interweaving of agriculture and open data to achieve food and nutritional security.

The GODAN initiative supports efforts to "make agriculturally and nutritionally relevant data available, accessible, and usable for unrestricted use worldwide." It focuses on "building high-level policy, and public and private institutional support for open data."[27] The initiative recognises 14 key data categories at this nexus with geodata, weather data, and market data standing out as particularly impactful applications (GODAN 2019). GODAN details four key challenges expressed by their partners attempting to increase the use of open agricultural data:[28]

- Financial cost – smaller organisations lack funding for open data activities and there are high costs associated with employment and training in open data management. There is therefore a need for ensuring that good data management and open data is a funded mandate.
- Political buy-in by high-level private and public actors. This could be through advocacy and guidance, including the Open Up Guide for Agriculture.[29]
- Benefits to farmers – farmers face challenges with technologies needed to access open data and digital literacy. There is also a need for responsible data principles, including data ethics and data rights, to ensure that maximum benefit is meted out to the persons it is meant to benefit.
- Data standards.

[24] In the context of freedom of information, the most relevant intellectual property rights are copyrights, which means they exclude documents and data that would comprise industrial property rights, such as databases, patents, registered designs, and trademarks.

[25] Article 31 of the Constitution of Kenya establishes the right to privacy in declaring that every person has the right to privacy, which includes the right not to have— (a) their person, home or property searched; (b) their possessions seized; (c) information relating to their family or private affairs unnecessarily required or revealed; or (d) the privacy of their communications infringed; The Universal Declaration of Human Rights Article 29 asserts this fundamental human right. It is central to the protection of human dignity and forms the basis of any democratic society. It buttresses other rights, such as freedom of expression, information and association. The right to privacy embodies the presumption that individuals should have an area of autonomous action, free from arbitrary State intervention and from excessive unsolicited intervention by other uninvited individuals.

[26] Global principles on national security and the right to information, Tshwane, 12 June 2013. These principles declare that "no restriction on the right to information on national security grounds may be imposed unless the government can demonstrate that: (1) the restriction (a) is prescribed by law and (b) is necessary in a democratic society (c) to protect a legitimate national security interest; Activities that restrict the right to privacy, such as surveillance and censorship, can only be justified when they are prescribed by law, necessary to achieve a legitimate aim, and proportionate to the aim pursued.

[27] Godan, 'Mission'-<https://www.godan.info/pages/mission> on 18 November 2020.

[28] Godan, 'Challenges expressed by Godan partners'-<https://www.godan.info/pages/challenges-solutions> on 18 November 2020.

[29] Open Guide Up for Agriculture, -<https://openupguideforag.info/> on 18 November 2020.

5.3 Data Ownership and Privacy

In terms of making agricultural and farm data publicly available through an open-access platform such as KOD, the challenges that arise are mainly concerning ownership and privacy. The ownership of the data in relation to ownership in property law implies:

1. The right to use the good – in this case, to access the data with reasonable freedom considering prevailing challenges such as digital literacy, electricity and digital connectivity coverage gaps, and affordability of requisite devices;
2. The right to object to the use or transfer of the good – i.e. to control distribution to third parties and opt-in or out of advanced data applications such as AI; and
3. The right to the rewards or benefits accruing from the good – i.e. valuable insights, historical records, and metadata.

Legal ambiguity regarding who owns the data (farmers, data collectors, Agricultural Technology Providers (ATPs), landowners, financial lenders, the government, or any combination of the same) makes it difficult to answer certain consumer protection and ethical questions. Terms and conditions (e.g. data blocking provisions, particularly by ATPs) and commercial end-user agreements (e.g. from machine owners/manufacturers or leasers) can be grossly unbalanced as farmers have a weaker bargaining position and cannot negotiate for more equitable terms and conditions for their access to data.

Without standardisation, the lack of interoperability between different datasets and platforms lessens farmers' autonomy even further by eliminating the possibility of switching service providers. Historical datasets are quite important as, unlike private data in online platforms, agricultural data do not depreciate with time and can even increase in value as a long history can produce richer insights in some applications. These issues merit careful consideration even if they arise within the context of the government open data platform.

5.4 The Need for Agricultural Data Governance Protocols

The absence of legal and regulatory frameworks around the collection, sharing and use of agricultural data in Kenya contributes to the range of challenges currently facing farmers who are considering the adoption of smart farming technologies. This absence also poses challenges for establishing an open data platform, which would require clarity and consistency. Although this absence is common across most jurisdictions and not unique to Kenya, there is need for a more coherent and comprehensive policy and regulatory framework.

Many existing laws potentially influence ownership, control of and access to agricultural data with the associated lack of clarity forming significant barriers to entry for farmers (Wiseman, et al. 2019). Wiseman et al argue that, without transparency and clarity regarding such issues as data ownership, portability, privacy, trust, third party access and liability in the commercial relationships governing smart farming; farmers are reluctant to share their farm data. Particularly for smallholder farmers, contracts governing data transactions are complex and reduce their negotiating capacity (Zampati 2019). Potential applications in agriculture are attracting growing interest from food and agribusiness industry players, researchers, and policymakers (Wiseman, et al. 2019). Most of the research in data-driven farming concerns commercial agricultural production in developed countries. However, there is relatively limited attention to big-data-based solutions targeted at smallholder farms in developing countries.

There is a compelling need for a framework that governs agriculture data collection, collation, and dissemination responsibly and conscientiously. Due to the large amounts of data generated through data-driven farming, current data privacy and security regulations that are more oriented towards individualised than sectoral data may offer inadequate protection for agricultural data (Zampati 2019). However, from a smallholder farmer perspective – which is dominant in African agriculture – Kenya's conducive environment for digitisation, connectivity and friendly policy and governance framework, even though still with some gaps, sets a digital landscape that can provide a way forward in trialling data-driven agriculture solutions for smart farming in Africa.

6. Recommendations and Policy Considerations for Kenya Open Data Platform with Respect to Agriculture

The overwhelming proportion of farm data consists of non-personal machine-generated data. However, where there is personal data of farmers, the privacy provisions of Kenya's Data Privacy Act (DPA) certainly apply. The European Union's (EU) General Data Protection Regulation (GPDR) may apply in the context of engagement with the EU (e.g. through trade, financing etc). The questions of data ownership, ethical data management, and equitable use are considerably more daunting. They will merit special attention and further research and studies in order to develop the best policy framework for the platform. What is particularly obscure is the fundamental question of the ownership of data and the benefits to farmers that can accrue from the use of this data. The DPA imitates the GDPR model. The GPDR model makes a strong case for paying close attention to the fact that the digital profile of a data subject must be protected from exploitation and abuse. This is not just a matter of protecting identities in the big data age but can also be essential in inspiring the confidence of data subjects to make the most of digitisation. Agriculture in Kenya can stand to gain by pursuing developmental goals that incentivise early adoption and innovation through KOD or similar initiatives for open access data. If realised, Kenya's leading role in Africa's technological space will be significantly augmented, contemporaneously to the operationalization of the AfCFTA.

The GDPR, which came into effect in May 2018, is an exemplar of data protection regimes. It outlines the EU law on data protection and privacy for all individuals within the EU and the European Economic Area. However, the GDPR is relevant because it has an extraterritorial scope. It applies to businesses and organisations both based within the EU as well as those that target the EU. Under the GDPR, there are strict regulations on what organisations can do with individual datasets as well as extensions on the rights of individuals to control how their data is used.[30]

There is a need for clarity and development of a robust set of policies and standards for data collection, integration, analysis, and profiling. The goal in doing this would be to enable consistency across different data handlers and applications, while respecting the integrity of personal information as an extension of the natural person.

The core GDPR principles that are mirrored in the DPA are an inalienable part of responsible approaches to data management. They are substantive models for best practices. Although it is tempting to pool together as much data as possible to facilitate as many insights as possible, the omnipresent threat of data misuse must be regarded as an unacceptable but inevitable dimension of the foray into digitisation. The threat is not solely external. Data handlers must themselves implement safeguards to ensure that farm and individual farmers and household data are collected and used on a need-only basis. In this regard, scoping out potential data use cases, their implications on personal identity, and appropriate measures to secure the integrity of Personally Identifiable Information (PII) are core considerations. So too are the commitments to focus on collecting only relevant data and keeping such data in as relevant and accurate a state as possible. This not only preserves the integrity of data subjects but also makes their data considerably more useful for accurate decision-making. Codes of conduct for data handlers should be designed along these lines and used to assess the compatibility of their data management approaches with the human ends of increased digitisation.

[30] The relevant core GPDR principles are; 1) lawfulness, fairness and transparency; 2) purpose limitation; 3) data minimization; 4) accuracy; 5) storage limitation; 6) integrity and confidentiality.

6.1 Data Collection

Although each instance of data collection will have its specificities depending on the collector, subject, and purpose; the following measures should form the core directives on data collection:

- A well-defined data collection purpose that is aligned with its specifications for data sample size, level of anonymisation, data volume, granularity, and security protocols;
- Clear communication to data subjects on the need and intended use of the data;
- Functional autonomy for data subjects to opt in and out of specific data parses and applications without facing the risk of outright denial of service; and
- A premium on data quality ensuring the accuracy, timeliness, and completeness of data collected from both farms and farmers.

6.2 Data Integration

Data integration entails the compilation and linking of collected datasets and databases into a metaset that has enough complexity for the desired data application. Such processes should be guided by:

- Separation of administrative functions (data services delivered to the public) and policy functions (steps taken to establish, evaluate and modify the platform) to prevent integrating data from two kinds of subjects with divergent expectations of what their information will be used for;
- Collation of datasets based on the defined data collection purpose;
- Retention of personal information for the minimum amount of time required to complete the purpose of data collection; and
- Precautions against an overly connected approach to integration that allows for more detailed insights to be drawn about the data subject than are necessary for the data collection purpose.

6.3 Data Analysis

Adequate precautions against low quality, biased, or discriminatory data sets to mitigate disruptive correlations ought to guide data analysis. In addition, adequate care must be taken to avoid spurious correlations and; instead, maximise meaningful correlations.

6.4 Data Profiling

Data models in agriculture are likely to be heavily imbued with profiling. This acts as a means towards the accurate prediction of the contribution of sets of data subjects to their associated value chains. This can form the basis of several use cases, from identifying viable partnerships to keeping track of programme beneficiaries for policy evaluation. The dehumanising transmogrification of data subjects into data points is a considerable concern in this stage:

- Transparency in the process by which profiles are generated to ensure that data subjects are informed of their predictions where appropriate; and
- Verification of predictions by accessible model testing that allows data subjects to challenge or respond to datasets.

6.5 Modelling the Kenya Open Data for Agricultural Digitisation

As has been previously inferred, KODI currently provides the best possibility for a publicly accessible agricultural database in Kenya. KODI can expect to receive data from a mix of traditional and new data sources to provide data that can be of relevance for analytics and agricultural. The data required for this modelling encompass: As has been previously inferred, KODI currently provides the best possibility for a publicly accessible agricultural database in Kenya. KODI can expect to receive data from a mix of traditional and new data sources to provide data that can be of relevance for analytics and agricultural. The data required for this modelling encompass:

- First, data collected by government for monitoring purposes, management of information and administrative

6.5 Modelling the Kenya Open Data for Agricultural Digitisation (continued)

procedures. These data, which include national statistics, weather data, monitoring data for subsidies and taxes, and data to monitor environmental performance and agricultural performance. These data are generally uniform in format and are usually collected on a regularly scheduled basis for as long as they are relevant for policies.

- The second source of data are research projects that collect data to meet specific project needs. These data are often incidental (i.e., collected on an irregular schedule) and not structured (i.e., non-uniform in format). In the agricultural space, the biggest player in national agricultural research systems is KALRO. Its formation was aimed at restructuring agricultural and livestock research into a dynamic, innovative, responsive and well-coordinated system. This system was to be driven by a common vision and goal of promoting, streamlining, co-ordinating and regulating research in crops, livestock, genetic resources and biotechnology in Kenya. In addition, this system was to expedite equitable access to research information, resources and technology and to promote the application of research findings and technology in the field of agriculture. Research projects data are open access by nature and is easily shareable under KODI's proposed agriculture platform. In most other cases, such as for instance university research, the data may not be shareable due to funder or intellectual property ownership impediments.
- The third source of data includes farmers, business-to-business service operators and Non-Governmental Organisations (NGO) that collect data for their own operations. They do not usually share data due to competition or privacy concerns. In Kenya, this third category will significantly include data collected by donor-led non-profit organisations that target support to the smallholder farmer. The expectation is that, if the gap between actual and potential yields can be closed, smallholders will grow sufficient crops to feed their families, with a surplus to sell, thus meeting food security needs and bringing in an income to move them out of poverty.[31] This third category has a proximate relationship to actual farming operations. These are the generators of agricultural data in real-time, or are involved in the data collection on a routine and systematic manner. Further, the proliferation and advances in internet network and mobile technology have led to the growth of crowdsourcing. Crowd-sourcing either allows GPS to enable mobile phones to act as sensors that can directly relay data online (with accurate location and timing information) or that allow specific applications to be developed. Such applications can be used in the farm for capturing relevant observations for the agricultural enterprise. These crowdsourcing technologies offer the opportunity to scale data collection while lowering operational costs. In these cases, farmer generated data can plug directly into KODI's open platform for agriculture.

These data sources ultimately lead to a proliferation of data that is potentially available for research. However, these data may be closed either technically or legally. KODI thus presents an opportunity to not only raise awareness on the value of open data but also in playing a leading role in promoting methods of availability and accessibility. Within KODI's agricultural platform, government, international organizations, research institutions, NGO's and businesses can co-operate to offer open access to their data and datasets to make analytics and re-use easier. From a legal standpoint, clear licensing arrangement should facilitate ease of access. KODI's embrace of Open Government Licences (OGL) from the outset provides a simple roadmap that gives clear rights and obligations to the users of data. It needs to be endorsed for use in agricultural analytics and modelling.

[31] Gassner A, Harris D, Mausch K, Terheggen A, Lopes C, Finlayson R, & Dobie P, 'Poverty eradication and food security through agriculture in Africa: Rethinking objectives and entry points' 48(4) Outlook on Agriculture, 2019, 309–315.

6.6 Conclusion

The considerations outlined in this section are equally applicable to both private and public sector actors as a basis for responsible data management from collection to the use of datasets for real-world modelling. The KCSAP open data platform can be a powerful introductory tool to Kenya's foray into a centralised approach to guiding data-driven agriculture approaches. However, the challenge in doing this lies in the fact that only government entities and agencies can input data into the platform. This is nonetheless a challenge that coalescing non-public sector actors and stakeholders around KALRO (with KALRO acting as the medium to the Kenya Open Data platform) can potentially overcome. While this has the potential to secure the quality of data and insights by minimising opportunities for mistakes or misuse, it might also lead to disproportional empowerment of the public sector. It might also shut out more cost-effective methods of accurate and timely data collection by private firms and individuals.

It may be that KALRO and national government agencies alone should not, therefore, be the only contributors to the platform in the long run. Agriculture is a devolved function of county governments whose extension officers have closer interactions with smallholder farmers.

There is a need to involve county governments, possibly through the Council of Governors Committee for Agriculture, as key stakeholders in collecting and inputting data into the platform. The Council of Governors is a legal public entity established by statute. This gives it the ability to input data in the open access data portal.

If availed, the ability for the platform to garner high-quality data from private sector actors, civil society organisations and individuals will be an important design feature in subsequent iterations of the platform. Decentralised data collection based on need would not only incur lower administrative costs in the long run but would also open the platform for value-adding applications not yet conceived. This is contingent, however, on the proper formulation and implementation of data guidelines to promote high-quality data collection, accuracy, timeliness, confidentiality, control and data sharing without too much oversight. As with most digital information systems, governing laws can be designed and programmed into the structure of the platform to stop its misuse. However, this would warrant a more in-depth study that does a comparative analysis of what has been done in other jurisdictions, if any. It would also warrant coming up with a model that would meet Kenya's needs and laws as well as and international standards.

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