The Status of ICT Infrastructure, Innovative Environment and ICT4AG Services in Agriculture, Food and Nutrition in Kenya

Makini F.M., Mose L.O., Kamau G., Mulinge W., Salasya B., Akuku B., and Makelo M.

Corresponding Author
Felister Makini

About FARA

The Forum for Agricultural Research in Africa (FARA) is the apex continental organisation responsible for coordinating and advocating for agricultural research-for-development. (AR4D). It serves as the entry point for agricultural research initiatives designed to have a continental reach or a sub-continental reach spanning more than one sub-region.

FARA serves as the technical arm of the African Union Commission (AUC) on matters concerning agricultural science, technology and innovation. FARA has provided a continental forum for stakeholders in AR4D to shape the vision and agenda for the sub-sector and to mobilise themselves to respond to key continent-wide development frameworks, notably the Comprehensive Africa Agriculture Development Programme (CAADP).

FARA's vision is; "Reduced poverty in Africa as a result of sustainable broad-based agricultural growth and improved livelihoods, particularly of smallholder and pastoral enterprises" its **mission is the** "Creation of broad-based improvements in agricultural productivity, competitiveness and markets by strengthening the capacity for agricultural innovation at the continental-level"; its **Value Proposition is the** "Strengthening Africa's capacity for innovation and transformation by visioning its strategic direction, integrating its capacities for change and creating an enabling policy environment for implementation". FARA's strategic direction is derived from and aligned to the Science Agenda for Agriculture in Africa (S3A), which is in turn designed to support the realization of the CAADP

About FARA Research Result (FRR)

FARA Research Report (FRR) is an online organ of the Forum for Agricultural Research in Africa (FARA). It aims to promote access to information generated from research activities, commissioned studies or other intellectual inquiry that are not structured to yield journal articles. The outputs could be preliminary in most cases and in other instances final. The papers are only published after FARA secretariat internal review and adjudgment as suitable for the intellectual community consumption.

Disclaimer

"The opinions expressed in this publication are those of the authors. They do not purport to reflect the opinions or views of FARA or its members. The designations employed in this publication and the presentation of material therein do not imply the expression of any opinion whatsoever on the part of FARA concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its frontiers".

Acknowledgement

Executive Summary

This report provides an assessment of the ICT infrastructure, the enabling regulatory framework and the state of deployment of ICT services in agriculture by various service providers in Kenya. On infrastructure, Kenya is served by the East African Submarine *Cable System* (EASSy), the East African Marine System (TEAMS), the Lower Indian Ocean Network 2 (Lion II) and Seacom cables. The cables provide high speed internet connectivity ranging from 193 to 2,840 gigabytes per second (GBPS) and comprises a bundle of glass threads each of which is capable of transmitting messages modulated into light waves. On land, the country is served by six major terrestrial broadband providers, namely: Safaricom, Liquid Telecoms, Internet Services (IS), Telkom Kenya, Jamii Telecom and Wananchi Online. Safaricom has the highest coverage and is closely followed by Liquid Telcoms and Telkom. In addition, Kenya has a National Optic Fibre Backbone Initiative (NOFBI) which is a joint venture between Kenya and Chinese governments, with the aim of connecting all national and county government agencies.

There are five major operators, Safaricom PLC, with a market share of 64.2%, followed by Airtel, with a 22.3%, Telkom Kenya Limited, Finserve Africa Limited and Mobile Pay Limited at 9.0%, 4.2% and 0.2%, respectively. A report released by the International Data Corporation (IDC) indicated that as at 2017, Kenya mobile subscription surpassed 40 million, with 90.4% mobile penetration of the adult population. Despite this impressive mobile penetration, internet penetration was less than 10%. Conversely, there is a big disparity in regional access to computers in Kenya, with Nairobi residents having the highest access, while North Eastern, Western and Coast have the least access. These ICT end user devices and their applications are mostly driven by off-grid and on-grid electric power; users' habits, preferences and trends are the key drivers in the choice of use, with SMS, email, social media, browsing and direct call being the major uses.

The journey of Kenya's ICT sector liberalization had several setbacks owing to the stringent conditions set by the regulator; but through advocacy and legislation, the sector was liberalized. Within a short period, the government has become a key facilitator and advocate of the use of ICT through creation of a state department of ICT and the rolling out of various initiatives, such as e-government, Konza city NOFBI, and open data. Improvements in the regulatory framework, capacity building of the young generation, establishment of the various incubation hubs, such as i-hub, Nailab, and others have led to the emergence and development of useful ICT systems, such as mobile applications and prototypes. However, to sustain the gains made in the ICT environment, the current support provided by the government to the ICT sector will need to be doubled. Moreover, for seamless operations, the array of players that include network operators, software developers, content providers, device manufacturers, government agencies and users have to work closely together. It is also apparent that sectors such as agriculture, health and manufacturing need to grow to the same level as the financial sector. This will only be possible if the requisite enabling environment is developed and maintained.

Various ICT4Ag service providers have been active in the Kenya mobile application (M-apps) environment. A total of 68 service providers were identified and analysed to understand how they work. The providers were grouped into seven clusters; the information-providing cluster had the highest number of m-apps, which implied the need to remove the information asymmetries in the agricultural sector, particularly in the rural areas.

In conclusion, the study established that the government of Kenya and the private sector have heavily invested in ICT, especially in the provision of support infrastructure. However, information on levels of access to various networks, such wireless access and connections, was scanty and, therefore, needs further studies. It is clear that ICT is recognized as a major enabler in both national and sectoral policies and strategies. However, this has not been experienced in the agricultural sector, due to lack of specific policy, legal and institutional frameworks to support the sector's peculiarities, including conservatism and risk aversion.

Based on the conclusions, the following key recommendations were drawn:

1. The Kenyan government should consider providing incentives to the private sector to broaden services, especially in the ICT for agriculture sector to spur innovations in service provision,
2. There is need to support a study on digital literacy in the ICT sector and particularly in the ICT4Ag service providers,
3. There is need to develop a robust legal and institutional framework for agriculture ICT to spur growth and innovation, and
4. There is need to standardize models of financing service provision that will provide a level playing field for all investors in ICT.

Introduction

Background

There has been significant progress in the growth of internet connectivity and international communication over the past decade in Kenya (ICT Authority, 2014). Previously, the country relied mainly on satellite connection; however, with the introduction of international broadband highway into the country in 2009, the number of internet service providers increased significantly. The impressive growth was also engineered by other factors, including enactment of supportive laws, policies and regulations and adoption of digital innovative solutions.

Subsequently, Kenya is considered an advanced digital environment among African countries, with an Information Communication and Technology (ICT) index score of 7.0 out of 9.0 (MercyCorps, 2019; World Bank, 2017). The country offers an enabling environment that promotes the provision and use of ICT services, particularly in rural areas through a system of laws, regulations and policies. Kenya is also ranked third in sub-Saharan Africa as per the Global Innovative Index (GII) ranking of 2018 (GSMA, 2018). The GII ranks South Africa as the most innovative country in Africa, followed by Morocco and Kenya (GSMA, 2018). According to GSMA (2018), Kenya has a good performance, especially on the price of handsets, gender equality and network coverage based on the Mobile Connectivity Index (MCI), where 85% of the population has access to 3G coverage. Consequently, access to mobile phone has increased from 5% in 2000 to 91% (46.94 million people) in 2018, in comparison to 80% mobile penetration in Africa (Kenya Mobile White Paper, 2019).

The increased penetration of mobile phones in Kenya has eased the aggregation and analysis of agricultural data with the potential to reducing information asymmetry in the agricultural sector and, hence, improving agricultural market performance at the macro level (Nakasone *et al.*, 2013). Consequently, the Government of Kenya planned to invest US$60 billion in infrastructure during 2013 - 2020 (including US$7.85 billion for ICT), although only US$25 billion was availed (CCK, 2008). Table 1 presents the budget allocation to ICT from 2013 to 2019, which was below the planned budget.

Table 1: ICT Sub-Sector Budget Allocation 2013/14 – 2019/20 Financial Years

ICT Programme	Budget allocation in Ksh billion						
	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
Cabinet Services	0.0503						
Single window support programme		1.1		0.3	0.3	0.3	
Public Financial Management	0.479	2.5					
Integrate IFMIS with other systems/Roll out		0.8	1.9	1.5	0.15	0.7	
Information and Communication Services	1.803						
Digital Migration							
Human Resource Management and Development	0.259	0.339	0.35				
Digital migration (KBC)				0.3		0.3	
Presidential digital talent				0.1		0.1	
General Administration services	0.217		1.61				
National Digital Services							
Research Development Fund			0.25	0.30			
Digital Literacy Programme (School Laptop Project)				13.4	13.4	11.9	3.2
Public Sector Advisory Services	1.612						
Government Shared Services							2.9
ICT Infrastructure Development	7.069	6.896	6.56				
National Optic Fibre Backbone Phase II							2.8
installation of an internet-based 4000 network							1.1
Development at Konza Technopolis Complex			0.8	0.9	0.6	8.3	7.2
Konza Data Centre and Smart City Facilities							5.1
Total	11.489	11.635	11.46	16.8	14.45	21.6	22.3

Source: The National Treasury 2013/14-2019/20. The Budget Summary for The Fiscal Year 2013/14-2019/20 and various support information (2013/14-2019/20); Price Waterhouse Coopers (PwC), 2013-2019.

It is notable that there is a rise in global digital transformation across many industries. However, the digital transformation in agriculture is being catalysed in diverse ways by certain global trends, which are bound to revolutionize the sector. These trends include farm robotics from

planting to harvesting, meat processing, and grocery logistics, and remote sensing, from in-field sensors, drones, satellite imagery, machine learning and analytics, among others. Although these have focused mainly on providing farmers with information across the spectrum of value chains, there has been limited impact recorded to date (AfDB, 2016). Other promising applications of ICTs, such as big data analytics, social innovations, internet of things and other disruptive technologies, are increasingly attracting attention, although they have not been widely applied.

In Africa, the agricultural sector has witnessed a proliferation of ICT-based initiatives, as mobile phones and internet subscriptions continue to increase (Verdier-Chouchane and Karagueuzian. 2016). Mobile phones and the Internet have a high potential to contribute to productivity improvement in the rural sector through reduction in market information asymmetries, increased demand for timely and precise technology information and improved linkages between agricultural value chain actors through texting (Deichmann *et Al.*, 2016). Like it is with other countries, the introduction of mobile phones in Kenya has brought a revolution in communication.

According to the Kenya National Bureau of Statistics (Consultoria, 2011; KNBS, 2017), the agricultural sector expanded by 7.1% in the third quarter of 2015, compared to 6.8% over the same period in 2014. However, demographic changes, such as population growth and urbanization, have placed immense pressure on the agricultural sector to produce more. As a result, different experts, researchers, practitioners, policymakers, farmers and other value chain actors have turned their focus on providing services to farmers using ICT. This trend has resulted in a notable increase in digital solutions aimed at improving agricultural practices, productivity and decision making.

Kenya has extensive opportunities for digital applications and analytics in agriculture as envisioned under the Agriculture Sector Transformation Strategy (ASTGS) (MoALF&I, 2019). The ASTGS targets the creation of several digital products that include digitally-enabled extension agents, formal digital and in-field; leadership training modules, digitally-skilled youth extension workers, digitization of the existing agriculture sector data, digital real-time data collection system, national digital water basin management system, development of digital platforms to provide services to farmers, real-time digital stock monitoring and digital subsidy registration and delivery systems. However, the country does not have mechanisms to control ICT-enabled extension contents. There is need to develop standards especially on contents and review the current extension policy.

Kenya is a pioneer in African agritech sector and has also dominated the market, accounting for 23.2% of all agritech start-ups in Africa (Disrupt Africa, 2017). Most agritech start-ups include financial services, such as mobile money, where 70% of the population has access to financial services. The agritech sector in Kenya is active with numerous companies and initiatives and burgeoning business models that are beginning to scale. Figure 1 shows the rapid growth of global mobile cellular telephone subscription and internet users, among other things.
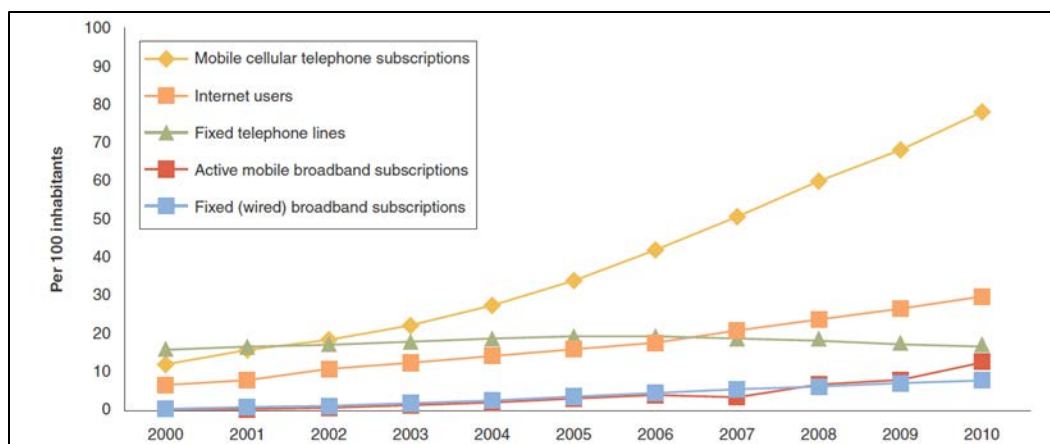
Figure 1: Global trend in information and communication technology, 2000-2010
Source: ITU World Telecommunication/ICT Indicators database (www.itu.int/ict)

A recent mission by the Bill and Melinda Gates Foundation identified and classified agritech organizations into the following (https://founder360mag.com/7-agri-tech-startups-disrupting-small-scale-farming-in-kenya/):

▪ Enterprise: Large established corporations providing agricultural solutions, e.g. Microsoft, Safaricom-Digi farms, SAP;
▪ Emerging: Companies or projects that have been in existence for some time (several years), are profitable or near profitable, have identified viable business models, have investors and are beginning to scale. Examples are iProcure, Amtech, Arifu;
▪ Start-up: Early stage companies with concepts or business models that are not yet fully tested and have not reached scale.
▪ Project: NGOs and funded projects that are piloting or testing a concept or solving for a particular need but are dependent on continued funding and support or have not reached a point of exit or transition to a sustainable business model, e.g. iCow.

McKinsey Report (McKinsey Global Institute, 2019) posits that agriculture is the least digitized sector in the world. However, there has been a steady emergence of technology start-ups in Nairobi. Consequently, Nairobi has earned a new title: The technology capital of the region – *Silicon Savanna* (Drafor, 2016). However, despite advancement in ICT, use of these technologies in the agricultural sector in Kenya has been slow, compared to other sectors, such as finance and insurance. This trend can be easily attributed to the conservative nature and lifestyle of farmers and other value chain actors. Therefore, there is the need to explore the entire ICT spectrum with a view to increasing ICT use in the planning and management of the agricultural sector.

Objectives
The broad objective of this study was to generate up-to-date information on the status of the ICT environment with regard to infrastructure, regulatory framework and the available ICT applications for agricultural service delivery. The specific objectives were to: (1) assess the status of ICT infrastructure, hardware and use; (2) assess the ICT regulatory framework in terms of

authorities, policies and regulations; (3) analyse the available ICT-enabled services in the agricultural sector along the entire value chain.

Organization of the Report

This report is organized in six sections. The first section covers the introduction, while the second presents the methodology used for the study, including research approach, data collection and analysis procedures. Sections three to five present the key findings (status of ICT infrastructure and innovation environment; the ICT regulatory framework and status of ICT4Ag services in Kenya, respectively), while section six presents the conclusions and recommendations.

Methodology

Research Approach

The study adopted a review approach, in which data and information on ICT infrastructure, ICT policy and institutional environment and ICT4Ag service providers were collected.

Data Collection and Analysis

Specifically, secondary data were collected from various published reports, papers and other relevant documents. Additionally, discussions were held with relevant individuals using a checklist of key issues to validate the secondary data and fill gaps.

Secondary data collection on infrastructure involved a collection of maps (or geo-referenced datasets) for key variables at the smallest resolution available, e.g. network coverage, network speed, location of phone masts, fibre optic cables, electricity grid, poverty rates, population densities, agricultural production and potential.

Data on ICT policies and institutions were collected through a systematic examination of a wide range of reports, published papers and other relevant documents. These covered the evolution of ICT sectoral institutions and policies, in addition to markets and funding.

A computer-based search of agricultural service providers (SPs) who used mobile apps yielded result for 200 providers. The providers were screened using criteria that eliminated those that had only scanty information, yielding a total of sixty-eight (68) active service providers. From the 68 service providers, information was collected on the following aspects: start date/end date, functions of the service, target users, value chain stage(s), ICT used for data gathering and analytics, ICTs used for dissemination; status of deployment, cost to users, funding / revenue generation model, and contact point and URL. The SPs were then clustered on the basis of function of their service.

Further screening was done based on availability of data, diversity of applications (apps) and expert knowledge to select five SPs that were submitted to Center for Development Research (ZEF) of the University of Bonn. From the five, ZEF selected three from which detailed case studies were carried out. The data and information collected were synthesized and presented in the form of narratives, tables and charts.

Status of ICT Infrastructure

In Kenya, the ICT infrastructure plays a substantial role in catalysing economic growth and other development programmes and is a leading enabler of such growth in many countries. Specifically, the Internet and mobile telecommunication infrastructure are the key drivers (Pradhan *et al.,* 2018) leading to a considerable increase in fibre optic and fixed broadband. In addition, connectivity and capacity have greatly improved, filling a substantial gap in infrastructure further increasing competition (Sutherland, 2014).

Extent of Fibre Optic Cables and Fixed Broadband

There is increasing availability of undersea cables across many African countries due to the recent surge in investment in this area (Sutherland, 2014). This is because ICTs are contributing and revolutionizing economic development, thus requiring good infrastructure. This includes a variety of cables to send and receive computer data, telephone conversations, photographic images, etc. and prevent interception and interference. Therefore, the Kenya government, in collaboration with both national and international partners, has invested heavily in ICT infrastructure through installation of undersea (marine), terrestrial and fibre optic cables besides facilitating various mobile telephony service providers.

Undersea cables network in Kenya

Kenya is served by four undersea cables on diverse geographical routes, namely: The East African Submarine Cable System (EASSy), The East African Marine System (TEAMS), the Lower Indian Ocean Network 2 (Lion II) and Seacom. Figure 2 illustrates the undersea cable network coverage in Africa and the access or landing points.
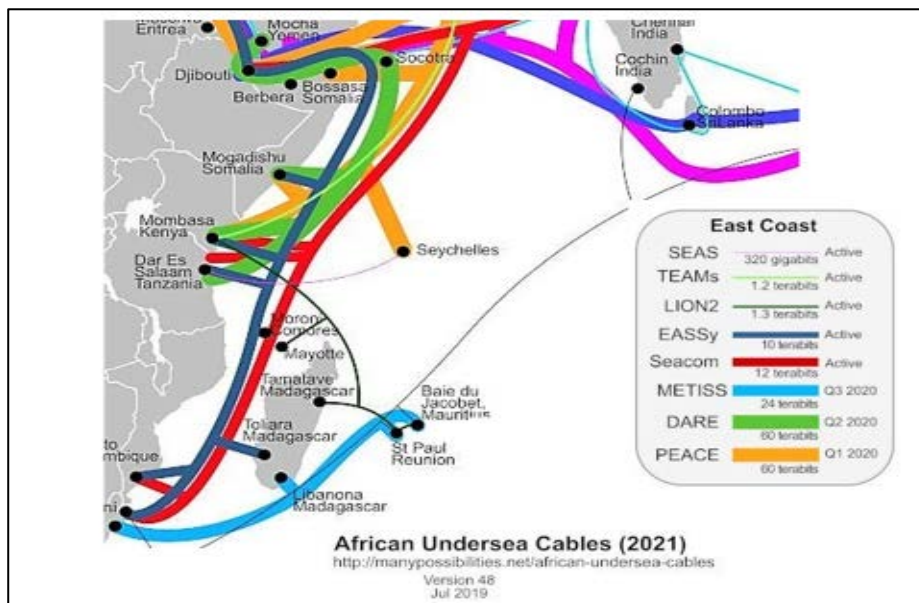

Figure 2: The distribution of undersea cables in Africa
Source: Extracted from: African Undersea Cables. Update July 2019 (Version 48)

http//manyposibilities.net/African-undersea-cables

a) The East African Submarine Cable System (EASSy)

EASSy was established through partial funding from the World Bank and was initiated on January 2003 following a feasibility assessment. The cable began service on 16 July 2010, with commercial services starting on 30 July 2010 (https://en.wikipedia.org/wiki/EASSy). It is the longest cable system serving Africa's eastern seaboard and links South Africa to Djibouti in the North East.

b) The East African Marine System (TEAMS

TEAMS is an initiative spearheaded by the government of Kenya to link the country to the rest of the world through a submarine fibre optic cable. It is a joint venture between the Kenya Government through Telkom Kenya and the United Arabs Emirates (UAE) through a telecommunications company, Etisalat. It covers approximately 4,500km and connects Kenya to the world via Fujairah in the United Arab Emirates (UAE). Its construction started in April 2009; and it was completed in June 2009. However, the operations started in September 2009 (https://en.wikipedia.org/wiki/TEAMS_(cable_system).

c) The Lower Indian Ocean Network II (LION II)

The Lower Indian Ocean Network II (LION II) is a submarine communications cable network that connects Madagascar, Mayotte and Kenya and was launched in April 2012 (http://www.fibreatlantic.com/system/Dk85n). It is owned by France Telecom and has 51% shareholding in Kenya through Telkom Kenya. This was France Telkom's attempt to use fibre optic cable to link other African countries and the world. It uses the SAT3/WASC8 cables on the West African Atlantic Seaboard and the SAFE network in the Indian Ocean

d) The Submarine Communications Cable (SEACOM)

SEACOM is a submarine communications cable operator with a network of submarine and terrestrial high-speed fibre optic cables that serves the East and West coasts of Africa. SEACOM's reach extends into Europe and the Asia-Pacific and is owned by a consortium of African and American companies and individuals. SEACOM landed in Kenya through Mombasa in June 2009 and became operational in July 2009 (GoK, 2014; https://en.wikipedia.org/wiki/SEACOM (African Cable System)). The initial capacity was designed at 12 terabytes per second (TBs), although currently the operational capacity is estimated at 500 gigabytes per second (https://en.wikipedia.org/wiki/SEACOM.

Terrestrial Broadband network penetration/coverage

Report from Safaricom, the leading provider of terrestrial broadband in Kenya, indicates that Kenya is served by six major terrestrial broadband providers (Safaricom internal reports). These are Safaricom PLC, Liquid Telecoms, Internet Services (IS), Telkom Kenya, Jamii Telecom and Wanainchi Online. In terms of distance covered, Safaricom PLC has the highest coverage.

Fibre network distribution in Kenya

Currently, the fibre optic network covers the major towns and cities in Kenya. There are also small-scale companies which do not have their own network infrastructure but rely on the main players. Such providers have little investment in physical infrastructure. Table 2 shows the ownership of TEAMS undersea cable in Kenya, while Figures 3a and 3b show the fibre network coverage. The data show that TEAMS is owned by 12 different firms. However, 80% share of

TEAMS is owned by only five firms, with the other 20% being shared among the remaining seven firms. The government of Kenya, Safaricom PLC and Telkom Limited each owns 20% shares. That means decision making in TEAMS is controlled by these five firms; the smallest five firms have only 1.25% shares each.

Table 2: Ownership of TEAMS Undersea Cable in Kenya

Firms that own TEAMS in Kenya	Ownership %
Government of Kenya (Ministry of Finance)	20
Safaricom PLC	20
Telkom Kenya Ltd	20
Kenya Data Networks Ltd	10
Econet/Essar Telecom Ltd	10
Wananchi Group	5
Jamii Telecom Ltd	3.75
Broadband Access/Access Kenya Ltd	1.25
Africa Fibrenet (Uganda) Ltd	1.25
InHand Ltd	1.25
iQuip Ltd	1.25
Flashcom Ltd	1.25

(Source: Sutherland, 2014)
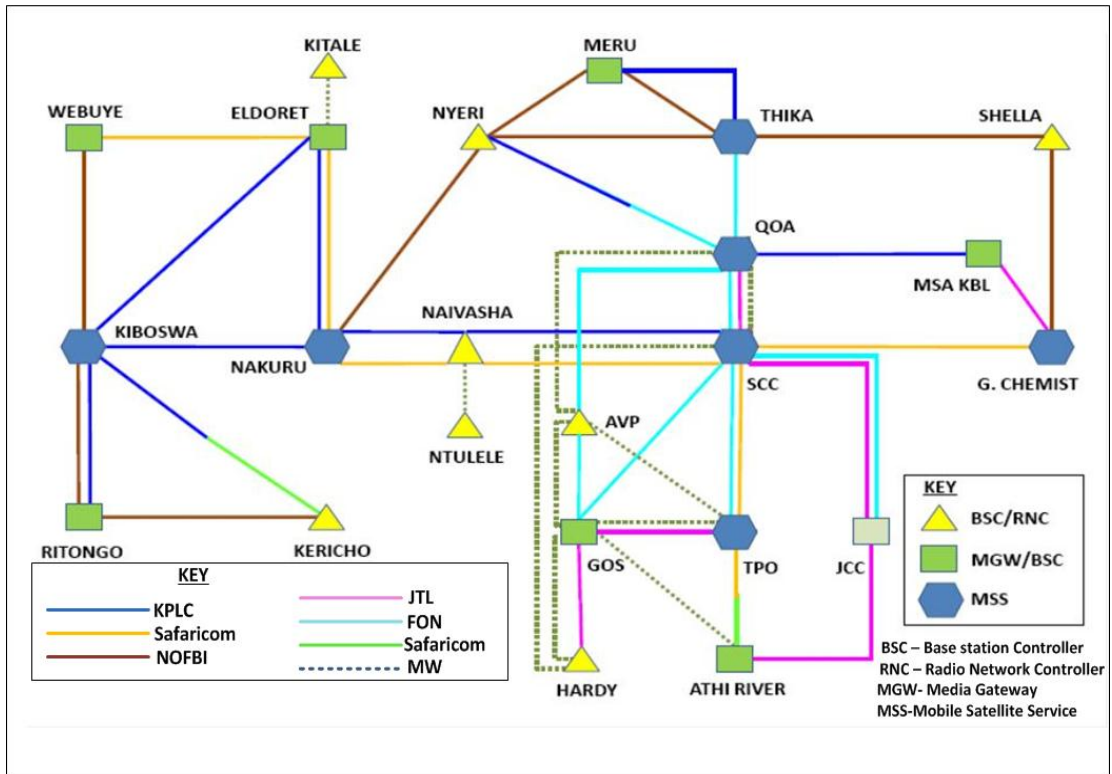
Figure 3: Extent of fibre distribution network in Kenya (Source: Safaricom PLC, 2019)

Key*: KPLC- Kenya Power and Lighting Company; NOFBI- National Optic Fibre Back-borne Initiative; JTL-Jamii Telecom Limited; FON-Frontier Network; MW-Microwave; AVP –Avenue Park; SCC-, GOS-, TPO -, QOA -, KBL are confidential locations of points of presence (pop)*
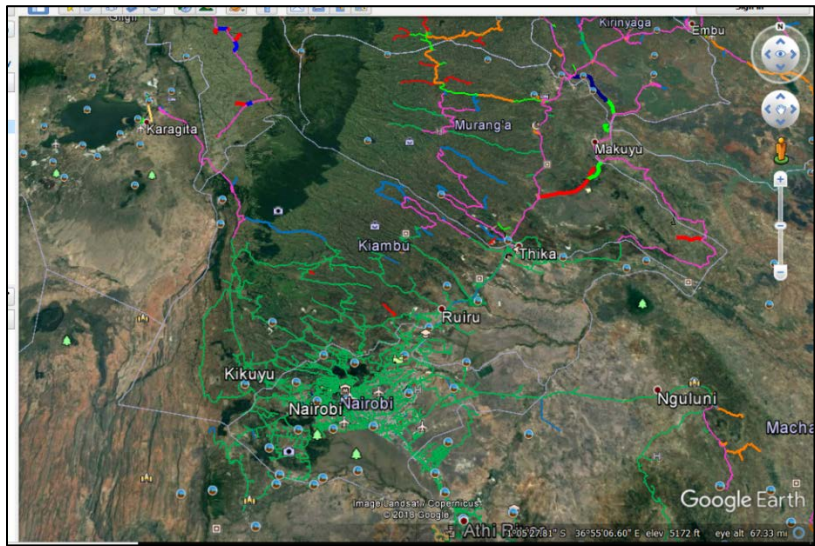
Figure 4: Extent of Fibre Distribution network in Nairobi (Source: Safaricom PLC, 2019)

National Optic Fibre Back-borne Initiative (NOFBI)

The Government of Kenya, through the National Optic Fibre Backbone Initiative (NOFBI), has established considerable fibre network in major towns and cities to connect all national and county government agencies. It is a project aimed at ensuring connectivity in all the 47 counties of Kenya, with the aim of easing communication across counties improving government service delivery to the citizens, such as application of national identity cards, passports and registration of birth and death certificates. The project is being implemented in 2 phases: NOFBI Phase 1, which covers 4,300km and NOFBI Phase 2, which covers 2,100km (Figure 5). This project is a collaborative effort between the Government of Kenya and the Chinese Government (funding), with Ministry of ICT as the project implementing agency. Telkom Kenya is charged with the mandate of overseeing operations and maintenance of the fibre network. The NOFBI network coverage is illustrated in Figure 5.
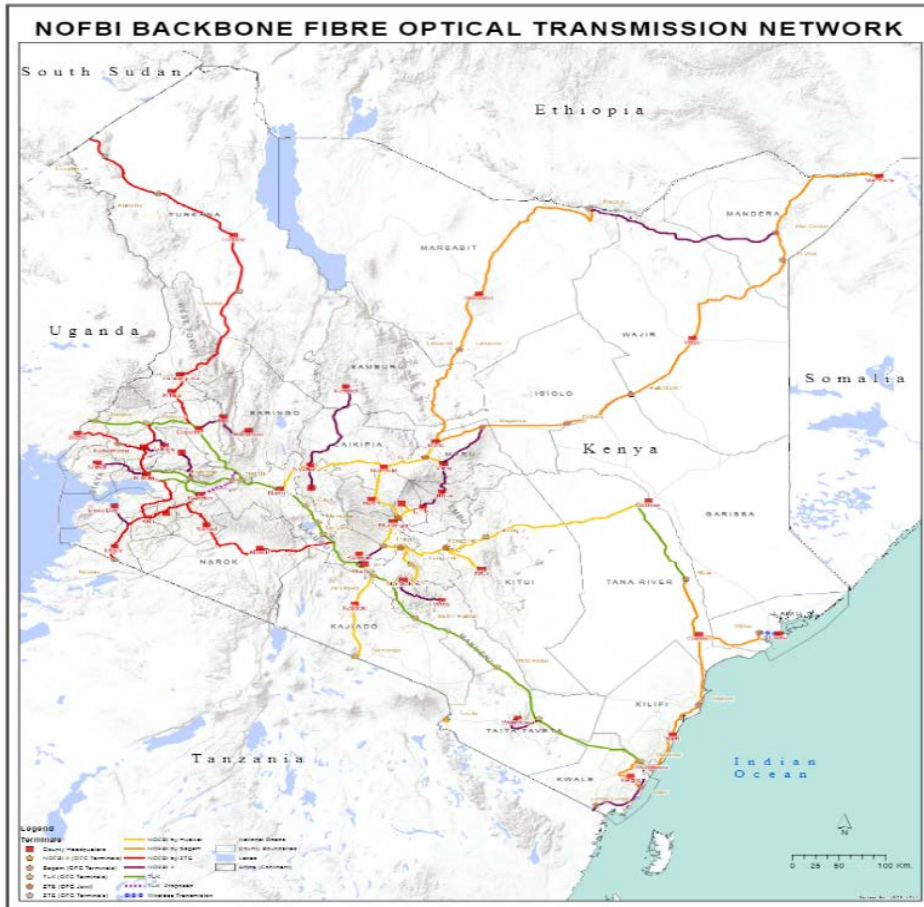
Figure 5: The National Fibre Optic Back-bone distribution map
(Source: http://icta.go.ke/pdf/NOFBI.pdf)

Quality of undersea cables in Kenya

Over the last decades, it is was becoming clear that technological advances would define the design of undersea cables, which provide different capacities through connections in Kenya. On the one hand, some providers use fibre optics, a technology that consists of a bundle of glass threads, each of which is capable of transmitting messages modulated into light waves. It is preferred over other technologies because of its advantages, including greater bandwidth than metal cables, hence carrying more data; it is less susceptible to interference than metal cables; it is thinner and lighter than metal wires; and it allows for data to be transmitted digitally rather than analogically; although, it is clear that its utilization is low and below the designed capacity. On the other hand, some providers use satellite traffic that allows the user to send and receive internet data using a satellite dish from anywhere within the coverage area of a particular satellite footprint. It, however, has low quality, mainly due to the design of the technology. Table 3 shows the designed capacity, available capacity and percentage in use, which has implication on the quality of internet connectivity provided.

Table 3: Available capacity on the undersea cables in Kenya

Cable	Designed Capacity Terabytes per second (TBPS)	Available Capacity in Gigabytes per second (GBPS)	Current % Usage
SEACOM	12	2,840	23.7
TEAMS	6.4	702	10.9
EASSy	10	828	8.28
LION II	1.28	193.	15.1
Satellite Traffic	N/A	5.72	N/A
Total	**29.7**	**4,623**	

Source: Communication Authority of Kenya (CAK) report, 2018

Notably, the proportion of current usage to designed capacity is low (<25%) for all cables. However, although the usage is low, in CAK (2018), it is recommended that the usage should be below 40% of available capacity, otherwise there will be need to upgrade the capacities. Conversely, the government's attitude to broadband network has been "build it and they will come" (Msimang, 2011). This is in line with Say's Law – supply creates demand.

Mobile Network in Kenya

This section of the report looks at the mobile network penetration in Kenya. The ICT infrastructure is considered the core component of the ICT ecosystem. The infrastructure comprises base transmitter stations for mobile networks, often loosely called transmission towers; the extent of fibre optic cables and fixed broadband, and international internet landing stations.

Mobile network coverage in Kenya

Mobile network coverage measures the percentage of inhabitants who are within the range of a mobile cellular signal, irrespective of whether or not they are subscribers. This is calculated by dividing the number of inhabitants within range of a mobile cellular signal by the total population. Since 2012, the mobile network penetration has been at least 89%. The current mobile network connection speed in Kenya is estimated at 13.7 megabytes per second (mbps), while the average mobile data connection speed in the first quarter of 2017 was almost twice as fast as the global average *(Personal Communication with Safaricom Staff, 2019).* Kenya has been ranked 28th globally, with an average speed of 10.7mbps. Figure 6 illustrates the mobile network coverage in Kenya.
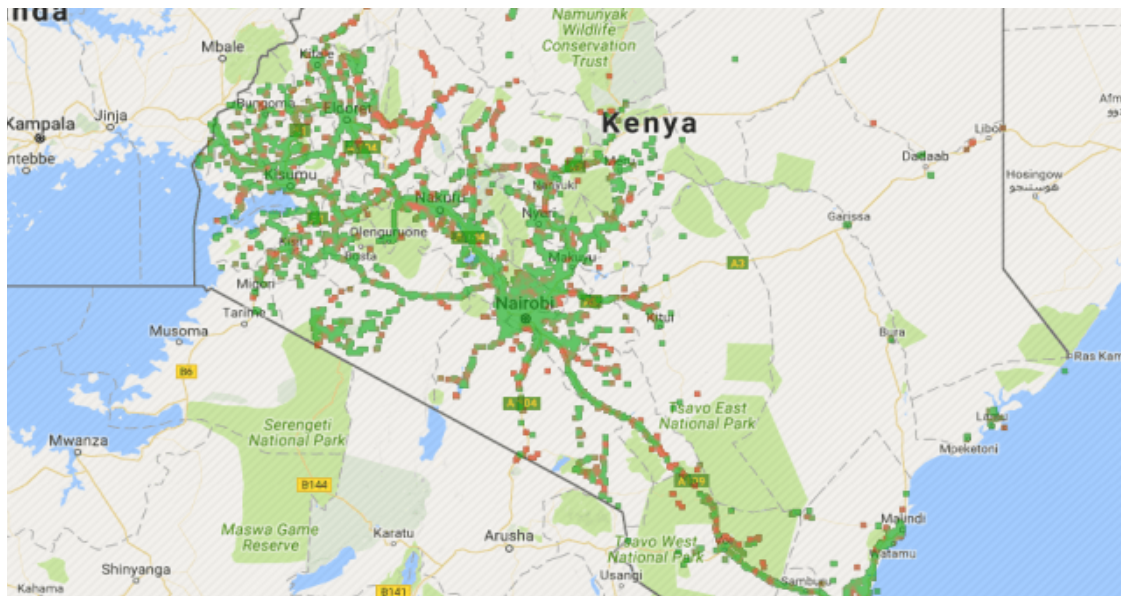
Figure 6: Mobile network coverage and distribution in Kenya (Source: Safaricom PLC)

Mobile broadband penetration in Kenya

There are four major mobile network operators in Kenya, namely: Safaricom PLC, Airtel, Telkom Kenya and Jamii Telecommunication (JTL). Jamii Telecommunication acquired its operating license in December 2017. The mobile market in Kenya has continued to grow steadily and, by early 2017, was supported by a mobile subscriber base of about 39.8 million (Njenga, 2018; https://www.internetworldstats.com/af/ke.htm). However, there was some market

consolidation following the acquisition of Essar Telecom's yuMobile business by Airtel and Safaricom PLC. While all network operators have invested in mobile technologies and infrastructure upgrades to support mobile data services, competition has nevertheless presented challenges to their profitability, leading to uneven revenue growth, as reported in recent years. The Communications Authority of Kenya's 2018-2019 report indicated that the number of active mobile subscriptions in Kenya stood at 46.6 million (CAK, 2019). The report further indicated that more than 30% of Kenyans own more than a single SIM card. This finding confirmed the Kenya Integrated Household Budget Survey (KIHBS) report released by the Kenya National Bureau of Statistics (KNBS) in April 2018.

With regard to market portfolio, Safaricom PLC has the highest market share of 64.2%, followed by Airtel Networks Limited (22.3%). Telkom Kenya Limited, Finserve Africa Limited and Mobile Pay Limited have market shares of 9.0%, 4.2% and 0.2%, respectively (Safaricom Internal Reports, 2019). Currently, Kenya ranks above other countries in sub-Saharan Africa on the average fixed mobile connection speeds. In 2013, a "National Broadband Strategy" was launched to extend fibre optic cables across the country, encourage more local content online, and install ICT centres at universities. As a result, broadband penetration coverage was estimated at 30% for the country in 2017, where the mobile broadband coverage of 3G was 85%, while that of 4G was one-third of the population. Safaricom PLC is leading in mobile network coverage in Kenya and is estimated at 96% on 3G and 4G (Figure 7).
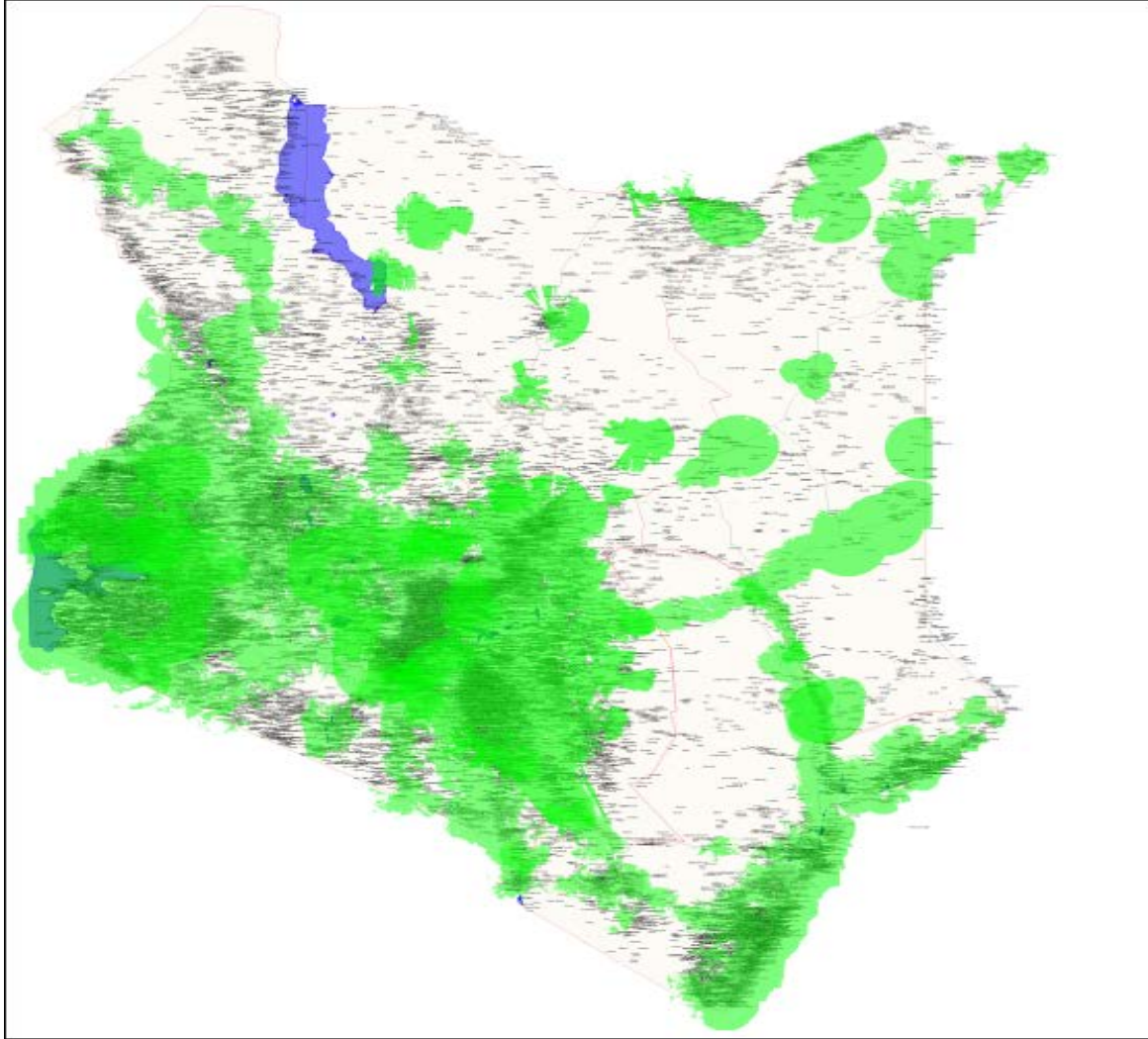
Figure 7: Safaricom PLC 3G/4G penetration in Kenya (Source: Safaricom Kenya Limited, 2019)

Conversely, the number of Kenyans owning mobile phones has also tremendously increased; although, the fastest mobile network internet connections in Africa are in South Africa, Ivory Coast, Morocco and Tunisia, followed by Kenya, as of February 2017 (Kenya Internet Stats and Telecommunications Report, 2019). Kenya is thus among the five leading countries with high mobile internet speed in Africa (Figure 8).
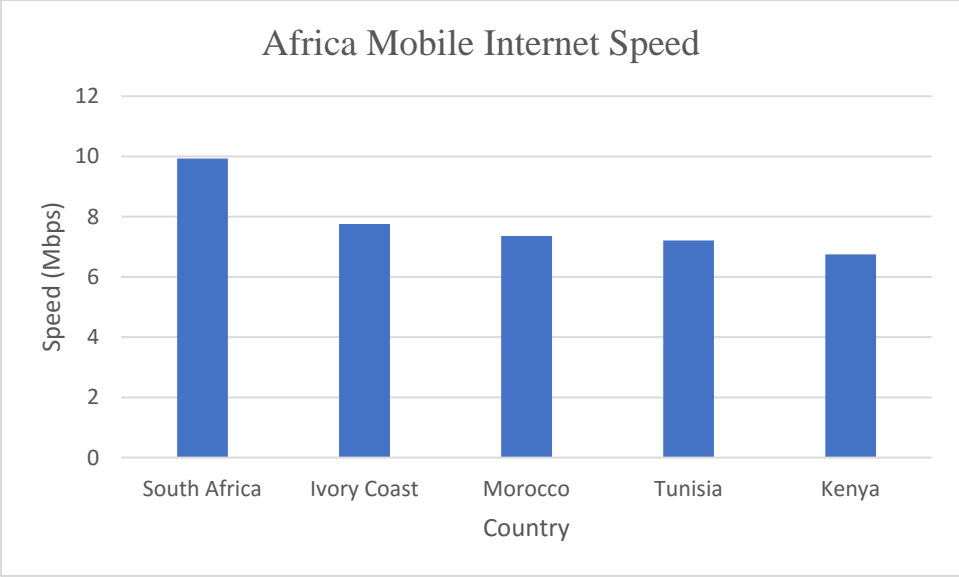
Figure 8: Mobile internet speed in five African countries, as at 2017
Source: https://kenyanwallstreet.com/fastest-mobile-internet-connections-africa-2017/

Kenya mobile network capabilities existing in second-generation (2G) were introduced in 1992 and use digital encryption conversations. Although the 2G network offers data services and text messaging, their data transfer rates are low. The third-generation (3G) network also exists, offering faster data transfer rates; it enables video calls, and is suitable for use in smartphones which require constant high-speed internet connection. The fourth-generation (4G) network provides ultra-broadband internet access for mobile devices and, due to its high data transfer rates, 4G networks are more suitable for use in USB wireless (https://ca.go.ke/the-digital-economy-blueprint/).

Types of end user devices used in Kenya
It is estimated that 3.6 million smartphones were sold in 2015 in Kenya. Smartphones account for 45% of all items sold on Jumia, with a notable sales increase of 244% between 2014 and 2015 (https://ca.go.ke/the-digital-economy-blueprint/). These results show that the mobile landscape is growing rapidly. Thus manufacturers have been consistently tailoring the smartphone devices to meet the needs and preferences of the local consumers within the African continent, leading to a variety of choices and prices in the market (Jumia, 2018). This has resulted in a greater variety of devices with a wider range of price points, leading to an increase in access to smartphones in Kenya, due to the reduced prices, a trend recorded in many other African countries, with Nigeria recording the highest access at continental level (Jumia, 2018). For instance, data show that the prices of smartphones tumbled down from $280 (Nigeria) and $200 (Egypt, Kenya) in 2013 to $100 in Nigeria and Kenya and $85 for Egypt.
Furthermore, the report indicated that in 2015 alone, 7 out of the top 10 smartphone vendors worldwide were Chinese mobile manufacturers (Jumia, 2018). However, a new trend is emerging, in which Asian brands are slowly becoming key brands in Africa. Despite this new entrant, Chinese

15

brands, especially the Infinix model, currently has the highest market share and is leading in 11 African countries, including Kenya, Nigeria, Morocco, Ivory Coast and Egypt (Jumia, 2018). Consequently, the study conducted in Kenya by Jumia indicated that habits and preferences in mobile usage influence access. The leading uses are email, social media and direct calls.

The high mobile phone penetration in Kenya has been driven by aggressive new entrants, especially China-based companies, and by price reduction. Figure 9 shows the different vendors and their market shares.
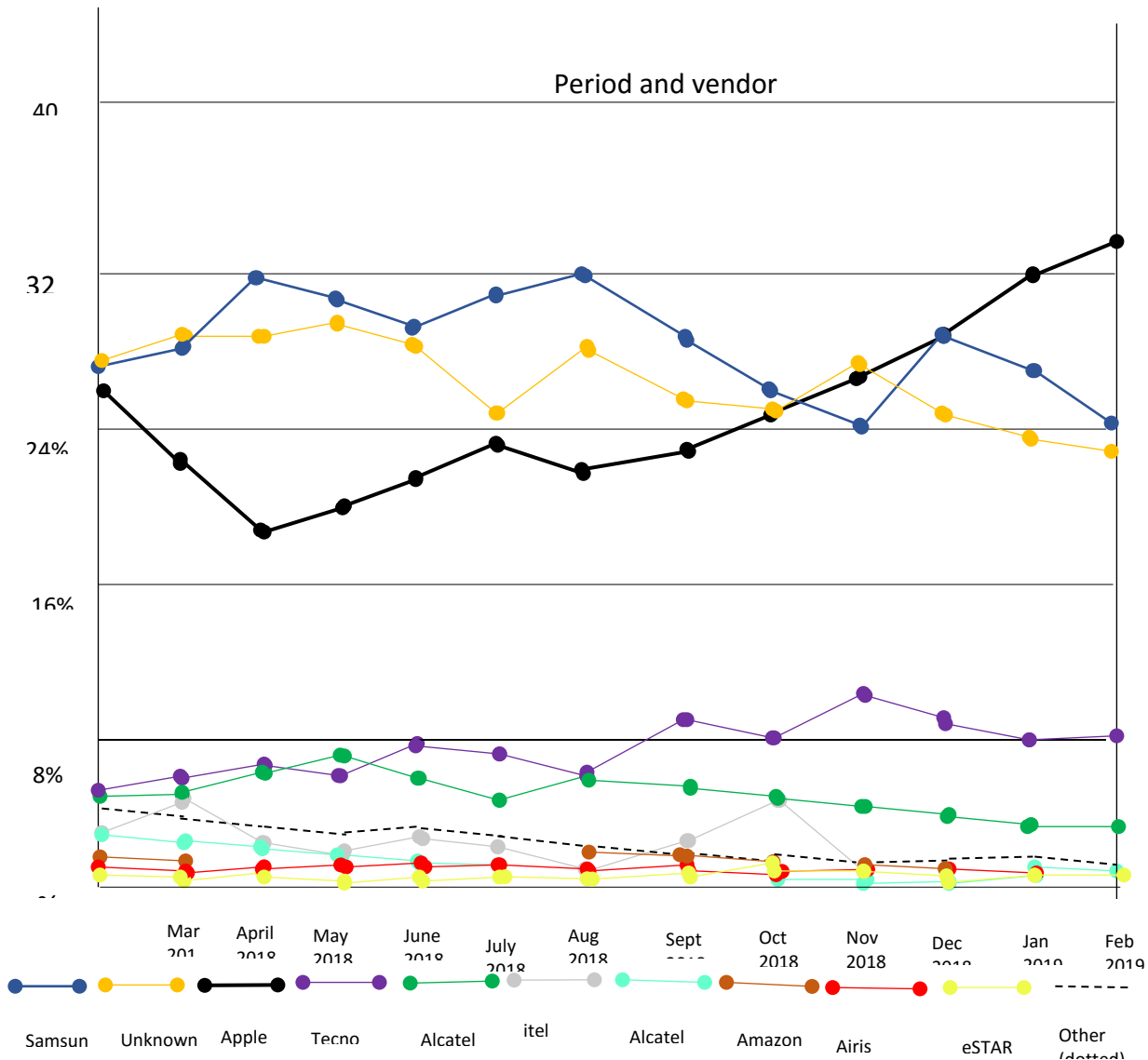
Figure 9: Vendors and their market share in Kenya
Source: IDRC report

In Kenya, a number of end user devices are used in the digitalization process. These include desktop and laptop computers, tablets, thin client and smart phones. Other end user devices are

16

projectors, digital cameras, printers, photocopiers, tablets, popplet, pen drives, IPods, IPads, web boards, scanners, microphones, interactive white board, DVDs, CDs, flash discs, and video games.

3.2.5 Access to ICT services

Access is broadly the ability to purchase or pay for ICT products and services. This could be availed either through public allocation or private ownership. The Integrated Household Budget Survey 2015/2016 (KNBS, 2018) pointed to a wide gap between the access to newer technologies, such as the Internet, and access to traditional technologies, such as telephone and radio. Table 4 shows the levels of access to selected ICT services in Kenya by age group.

Table 4: Proportion of population aged 3 years and above by ICT equipment and service used

Age Group (Year)	TV	Radio	Mobile	Computer	Internet	Population aged 3 years and above ('000)
National	47.8	79.1	68.2	9.5	16.6	41,751
3-5	36.7	69.5	28.8	1.7	0.4	3,806
6-17	40.4	76.0	45.9	4.6	4.2	14,483
18-35	60.5	83.7	90.1	18.4	36.8	13,136
36-70	48.4	82.5	89.2	8.7	15.6	9,336
70+	25.5	66.2	59.2	0.8	1.0	990
15-24	55.3	82.4	77.6	17.1	29.7	9,085

Source: KNBS, 2018

In addition, Annex 3 of this report (KNBS, 2018) shows the level of usage of digital services and digital appliances in the last 3 months from any location by main employer/business. A higher proportion of persons subscribed to money transfer platforms, such as M-Pesa, than to mobile banking platforms. Use of mobile phone as a digital appliance topped other appliances, such as radio, television and the Internet. The use of mobile phones by small-scale agricultural holders was comparable to its use by people in other sectors of the economy. On the average, one in every four persons did not have an active SIM card. Although, most persons working (apart from those in the private sector) have at most four active SIM cards. Majority of people owned one or two active SIM cards (Annex 4).

Further, Annex 5 shows the mean weekly airtime (in Kenya Shillings) spent on talk time, compared to internet movies and music. Most airtime was spent on talk time; the least airtime was spent on music and movies. The amount of airtime spent on agriculture-related activities was low (≤Ksh 100) compared to that of other sectors (≤Ksh 510).

Access to computers

Data from KNBS for 2015/2016 indicated that nationally, 9.5% and 16.6% of the population had access to computers and internet, respectively. Across the services, the proportion of the

population aged 18-35 had the highest access, with about 90% having access to mobile phones and 18.4% having access to computers, while 36.8 had access to the Internet.

Access to computers in different regions of Kenya

Regionally, Nairobi had the highest usage of computers, with 31.2% of the population having used them for 12 months preceding the survey, followed by Central at 10.0% and Nyanza at 7.4%; the lowest usage was Western, at 2.7% (Figure 10). The distribution mirrors the levels of ICT infrastructural development in the country (https://ca.go.ke/the-digital-economy-blueprint/).

It is important to note that the proportion of men who had used computers was 9.5%, compared to that of women, which was 7.3%.
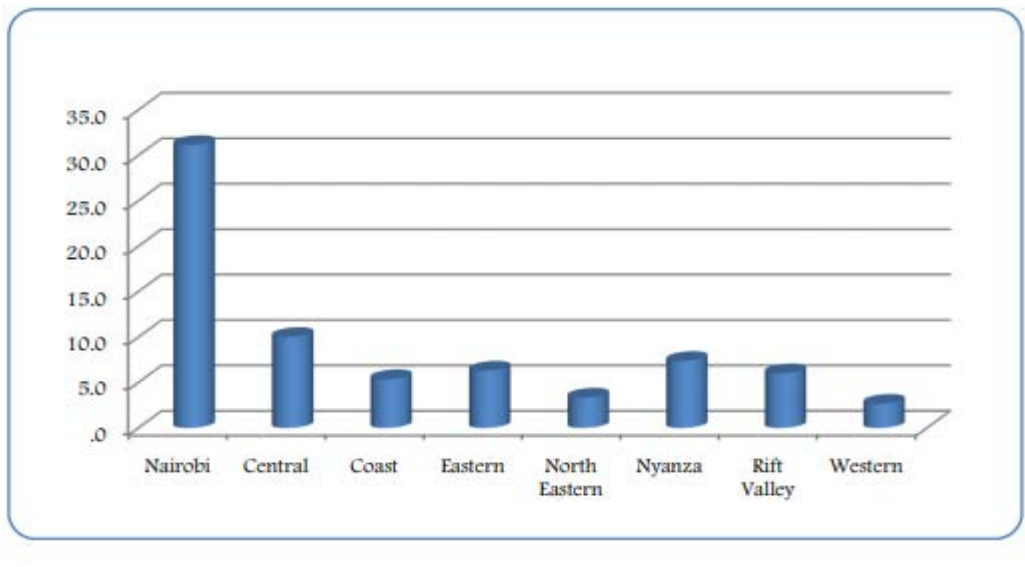
Y- axis refers to % access and X-axis refers to the regions of Kenya

Figure 10: Regional access to computers in Kenya
Source: KNBS, 2011

Internet connectivity growth in Kenya

Internet connectivity in Kenya has grown exponentially from 0.7% in 2000 to 89.4% in 2017 (Table 5).

Table 5: Internet Growth Coverage in Kenya from 2000 to 2017

Year	Users	Estimated Population	% Penetration	Source
2000	200,000	30,339,770	0.7	International Telecommunications Unit (ITU) report

2008	3,000,000	37,953,838	7.9	International Telecommunications Unit (ITU) report
2009	3,359,600	39,002,772	8.6	International Telecommunications Unit (ITU) report
2010	3,995,500	41,070,934	9.7	International Telecommunications Unit (ITU) report
2015	31,985,048	45,925,301	69.6	Communication Authority of Kenya (CAK) report
2017	43,329,434	48,466,928	89.4	Communication Authority of Kenya (CAK) report

Source: ITU, 2010 and CA, 2017

The Internet is used for different purposes. Annex 6 shows what the internet is used for (KNBS, 2018) by persons in different employment / business types in Kenya. The data show that it is mainly used for seeking information on health, and less on selling goods or services.

Access to electricity to operate ICT infrastructure

A recent report from the World Bank tracking global achievements in sustainable energy for all shows that Kenya has the highest (56%) rate of access to electricity in East Africa, compared to Tanzania (32.8%), Rwanda (29.37%), Uganda (26.7%) and Burundi (7.5%) (www.kplc.co.ke/content). In Kenya, as at June 2018, the effective installed (grid connected) electricity capacity was estimated at 2,651 metric watts (MWs), with a peak demand of 1,802MW. Conversely, the average annual electricity consumption per household in the urban areas was 2,501kWh, while in rural areas it was 208kWh per household; the average annual household power demand was 285W, with a maximum of 3.6kW. Rural access to electricity was approximately 48.4% and that of the urban population was 77.6% (www.kplc.co.ke/content/item/2485) with a load factor of 7.9%, compared to the interconnected system load factor of 69.9%.

Source of electricity

Figure 11 shows the structure of grid and off-grid electricity in Kenya.
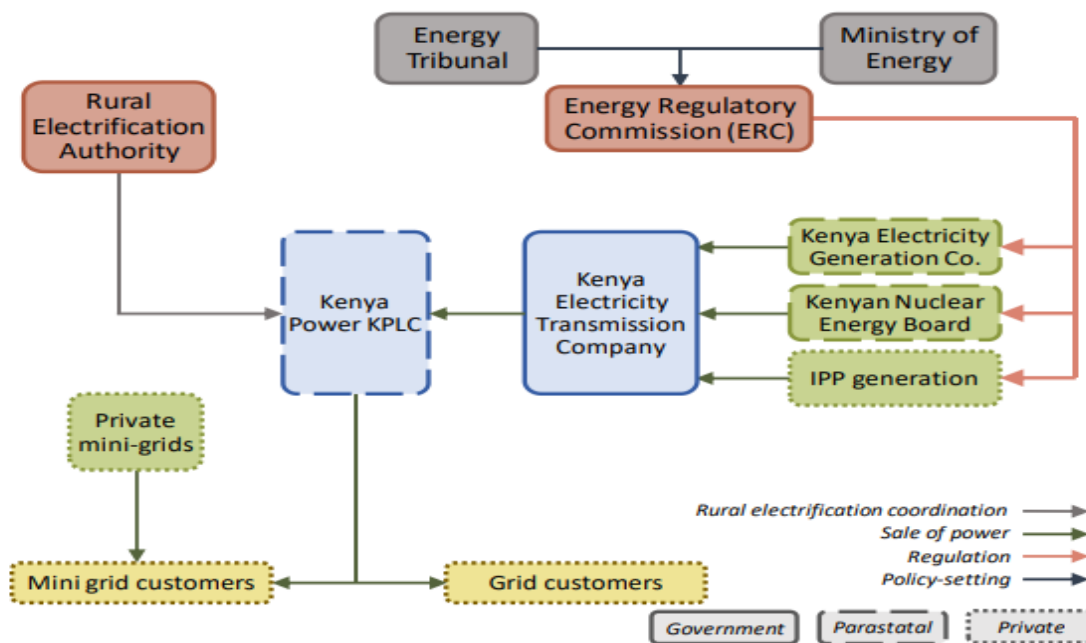
Figure 11: Electric Power structure in Kenya

Key: IPP is Independent Power Producer; KPLC is Kenya Power and Lighting Company
Source: GIZ, 2016

Off-grid electricity providers

There are several off-grid electricity service providers in Kenya, such as Mkopa; Power Gen, Steamco, Power Hive, and Green Power Engineering. *Mkopa Solar,* with its headquarters in Nairobi, is the market leader of "pay-as-you-go" energy for off-grid customers, with about half a million connected homes worldwide. *Power Gen* is a Kenya-based company with projects in Kenya, Tanzania and Zambia. It has over 15 operational micro-grid systems in Kenya (10+ for SteamCo) and provides stand-alone systems. With Clean Star Ventures, Power Gen has set up the GridX project at James Finlay Tea Estate, Kericho.

Steamco is a Kenya-based company providing industrial automation services to micro-grids and other technology types, including remote monitoring and pay-as-you-go systems. Its primary business is to provide information platforms and payment systems. The first micro-grid in Kenya was at Remba Island on Lake Victoria (for Power Gen). The company is active in Kenya, Tanzania and Nepal.

Green Power Engineering is also a Kenyan private company/NGO mix that designs, plans, develops and operates community-owned small hydro plants and distribution networks on the southern slopes of Mt Kenya. To date, Green Power has identified 10 sites, ranging from 60 to

500kW to supply up to 10,000 households. With government, donor and local community support one site has been built; although, the distribution network is not operational.

Power Hive is a California-based company with a Kenyan subsidiary developing village-scale renewable energy micro-grids, using solar with battery storage. Its primary business comprises information, monitoring and payment systems. Currently, the company has 4 sites in Kenya with a total capacity of 80kW (solar) and 300 customers. It was the first company after KPLC to be formally licensed in Kenya

Investments, Digital Economy and Literacy

According to UNESCO's Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2 Report (Law *et al.,* 2018), "digital literacy is defined as the ability to access, manage, understand, integrate, communicate, evaluate and create information safely and appropriately through digital technologies for employment, decent jobs and entrepreneurship. It includes competences that are variously referred to as computer literacy, ICT literacy, information literacy and media literacy". This refers to the ability to verify, interpret and validate digital information. Cyber literacy refers to competence with respect to using the Internet, communications and the Web. In Kenya, the ICT sector has been identified as pivotal to raising labour productivity and enhancing the country's competitiveness. While digital technologies permeate all spheres of life, fundamentally, they shape how people live, work, learn and socialize. Consequently, they provide opportunities to improve lives and connect people with others; although, these technologies marginalize those who lack essential digital literacy skills.

Digital literacy is vital for all citizens, which means equipping them with the skills to enable them to participate in the information society. However, digital literacy in Kenya is not in tandem with its ICT sector growth, which is a challenge. An assessment of six digital literacy frameworks from six countries using DIgicom 2 ranked Kenya's Basic Education Curriculum Framework as fourth, with an aggregate score of 38 (Law *et al*., 2018). Using results of a GSMA (2015) survey on ease of accessing mobile internet and need for assistance in using mobile internet as a proxy for digital literacy, Kenya was ranked seventh (52%) out of eleven countries based on the percentage of mobile phone owners who reported they had accessed mobile internet ahead of Indonesia, DRC, India and Niger (Table 6). The country was also ranked eighth (43%) of eleven countries, based on the percentage of mobile phone owners who reported they needed help using mobile internet ahead of DRC, India and Niger (Table 7).

Table 6: Percentage of Male and Female Mobile Phone Owners Who Report They Have Accessed Mobile Internet

No	Country	Male (%)	Female (%)	Average (%)
1	China	80	71	75.5
2	Mexico	74	68	71
3	Egypt	68	68	68
4	Jordan	64	59	61.5
5	Turkey	64	59	61.5
6	Colombia	62	59	60.5
7	Kenya	61	43	52
8	Indonesia	58	41	49.5
9	DRC	33	19	26
10	India	30	19	24.5
11	Niger	30	18	24

Source: GSMA (2015)

Table 7: Percentage of Male and Female Mobile Phone Owners Who Reported They Need Help Using Mobile Internet

No	Country	Male (%)	Female (%)	Average (%)
1	Mexico	20	20	20
2	Turkey	17	20	18.5
3	Colombia	25	27	26
4	Egypt	25	29	27
5	Jordan	22	29	25.5
6	China	30	37	33.5
7	Indonesia	25	49	37
8	Kenya	37	49	43
9	DRC	58	75	66.5
10	India	61	76	68.5
11	Niger	61	81	71

Source: GSMA (2015)

In order to increase the levels of digital literacy in 2013, the Government of Kenya initiated the Digital Learning Programme (DLP) which targeted the provision of digital skills in all public primary schools through the integration of digital technologies in learning. This initiative was driven by the understanding that technology are defining the world; hence, the need to prepare young people for today's realities.

ICT infrastructure in Kenya has been steadily growing from 2009, following the introduction of international broadband highway. Consequently, the number of ICT service providers in agriculture equally increased significantly. The main uses of ICT in agriculture are in the multiple downstream (Table 8).

Table 8: ICT4Ag Use cases and Infrastructure in Kenya

Use cases	ICT4 Agriculture Infrastructure
Financial Access	1. Agricultural data management infrastructure for example farmer registries, farmer transactions, soil maps, weather, agronomy, pest and disease surveillance among others
Agricultural Advisory Services	2. Agricultural Software for examples customer relations management, enterprise resource planning solutions, data capture tools, field agent management tools, data analytics tools, block-chain platforms among others
Linkages to markets	
	3. Hardware infrastructure for examples, drones, satellites, geographical information and positioning systems, robots, field sensors, machinery sensors, portable devices for soil, crops, livestock and input diagnostics tools, internet of things and other remote sensing devices among others
Supply Chain Management	
Agricultural Data service intermediary and data Intelligence	

Kenya invested about 20 billion Kenya shillings in telecommunication infrastructure from 2012 to 2016 (https://kenyanwallstreet.com/fastest-mobile-internet-connections-africa-2017/); with regard to investments especially in the deployment of broadband across different parts of the country, Google, Microsoft and Facebook were significant. Data from the Communication Commission of Kenya (CCK) show that online markets in Kenya generated approximately KES 15.8 billion in the last quarter of 2017.

Recommendations
1. There are sufficient opportunities for funding, either by donors and private sector, to scale ICT for agricultural services to successful measures;
2. This study recommends the bundling of capabilities of digital or ICT4Ag services into seamless infrastructure using available platforms;
3. Opportunities to adopt a middleware ecosystem, especially in agricultural data infrastructure, exist and are critical;

4. The engagement of human agent networks will help support digital impact to be realized much faster;
5. In terms of data infrastructure, data privacy and security in agriculture should be addressed through effective policies and regulations, especially in the forthcoming data revolution, which is the 4th industrial revolution;
6. Kenya should invest more in digital infrastructural development, especially in data analytics infrastructure.

Review of Kenya's ICT Innovation Environment: Evaluation of Policies, Regulations, Markets and Funding

Introduction

It has been shown that in developing countries, information and communication technologies (ICTs) account for up to 17% GDP growth (World Bank, 2016). In Kenya, 12.9% growth was realized in the ICT sector from 2017 to 2018 (GOK, 2019). The statistics depict a major role that ICTs play towards realizing a turnaround in the economies of the developing countries. Kenya's ICT sector has over time attracted a lot of interest owing to the country's leap from a technologically backward state before 2002 to the current status of 'a force to reckon with' (Ndemo, 2015; Waema et al. 2010). Several factors contributed to this immense growth, key among them being a supportive government, development of ICT infrastructure, private sector involvement, relevant policies and job creation (Ndemo and Weiss, 2017; World Bank, 2016).

The early stages of the ICT sector in Kenya were characterized by various challenges due to the stringent requirements imposed by the Kenya Posts and Telecommunications Corporation (KPTC) and the telecommunications regulator and provider before 1999 (Mureithi, 2017; Waema, 2005; GOK, 1978). However, through incessant advocacy and lobbying by civil society organizations (CSOs), international NGOs and donors, the Kenya Information and Communications Act (1998) was formulated (Ndemo and Weiss, 2017; Waema, 2005). The Act facilitated the splitting of KPTC into five entities, Telcom Kenya, Kenya Postal Services, a national communication secretariat, a dispute resolution tribunal and the Communication Commission of Kenya (CCK) as regulator, (GOK, 2014, 1998; Waema, 2005). Telkom Kenya was given exclusive rights for five years (1999 - 2004) to control telephone and internet backbone gateway services (Mureithi, 2017). Civil society organizations, NGOs and other private stakeholders relentlessly lobbied and, eventually, the country allowed multiple players and hence introduced competition in the information and communication sector (Ndemo, 2015; Nxele and Arun, 2005). This section gives an account of Kenya's ICT environment, divided into: Kenya's ICT sector institutions' timelines, various policies, regulations, markets and funding, among others.

The Kenyan ICT Sector Institutions Timeline

This covers the evaluation of ICT sector in Kenya, discussed in three phases: from KPTC to CCK (1977 – 1998), from CCK to CA (1999 – 2013) and the current ICT sector (2013 to date).

The change in ICT regulator from KPTC to CCK, 1977 - 1998

The Kenya Post and Telecommunication Corporation (KPTC) was established in 1978 with an express mandate to provide and regulate postal, money transfer, telephone and broadcast services in the country (GOK 1978). The introduction of email communication in the 1980s and early 1990s led to the need for email communication between organizations operating in Kenya with their parent offices overseas (Mureithi, 2017; Waema, 2005). The communication was through desktop computers hooked onto modems using KPTC-leased telephone lines, which were very costly and slow; mails were checked and sent twice a day using reverse calls (Mureithi,

2017). As demand for email services increased, a workshop to deliberate on the service was organized in Nairobi by the Telecommunications Foundation of Africa (Waema, 2005). Following this workshop, the KPTC declared that transmission of emails amounted to illegal use of leased lines, which led to the ban on internet use in government offices up to 1999 (Ndemo, 2017). Following these developments, civil society organizations and international NGOs conducted spirited advocacy and this led to the formulation of the Kenya Information and Communications Act (1998) and its official launching in 1999 (GOK, 1998). The Act facilitated splitting of KPTC into three entities which were Telecom Kenya, Kenya Postal Services and the Communications Commission of Kenya (CCK) as the regulator. A national communication secretariat was also established as a dispute resolution tribunal and Telecom Kenya acquired a five-year monopoly to provide local and international telephone services, internet nodes and backbone and VSAT networks (Waema, 2005). In 1995, the African Regional Centre for Computing pioneered internet connection with a 32Kbps leased line, followed by Form-Net and Africa-Online, thus marking the onset of ISP competition (Mureithi, 2017). The newly created CCK had a mandate to regulate telecommunications and postal/courier subsector and to manage the country's radiofrequency spectrum. It also had the mandate to manage competition in the ICT sector and protect the rights of consumers within the ICT environment (KICA Act 1998; Kenya Communications Act 2009).

The change in ICT regulator from CCK to CA (1999 -2013)
The mandate of CCK was as delegated by the executive arm of the government; in 2009, regulation of broadcasting and e-commerce was added onto the commission's mandate. This transformed CCK to a converged regulator responsible for facilitating the development of the information and communications sector that included broadcasting, multimedia, telecommunications and postal services, in addition to electronic commerce (Kenya Communications Act, 2009). While the mandate of the commission was clearly spelt out, its powers were limited and depended on the executive arm of government to perform the day to day duties, which could lead to biased decisions. This was viewed as unfair and in the new Kenyan Constitution 2010, Article 34(A) directed that 'Kenyan media should be regulated by a body that is independent of the control by government, political, commercial or any other interests" (GOK, Kenya Constitution, 2010). In 2013, the government passed the Kenya Information Act, which repealed the KICA 1998, revised in 2009; it also passed the Media Council of Kenya Act, 2013 which repealed the Media Act of 2007 (KHRC, 2014). In 2014, the Communications Authority (CA) was officially launched to replace the CCK. The authority is managed by a board of directors comprising 13 members and a director general; it is organized into communications infrastructure, regulations and access, operations, legal enforcement, and risk management and internal audit teams. These teams are further subdivided into 12 directorates.

Current ICT Sector regulation (2013 – Present)
The Ministry of Information and Communications is in charge of all communication matters and, together with the communications authority (CA), participate in internet negotiations, formulation and implementation of ICT policies, development and administration of ICT standards and building capacity of the mass media, as well as dissemination of public information. The two departments (State Department of Broadcasting and Telecommunications

and the State Department of ICT and Innovation) are housed in this ministry. The role of the ICT department is to oversee the formulation of the National ICT and Innovation Policy, promote e-government and the software development industry, provide ICT technical support, and develop capacity and infrastructure (GOK, 2016). The State Department of Broadcasting and Telecommunication regulates and coordinates telecommunication, broadcasting, language policies, public communication, government advertising services and postal and courier services. The Communication Authority of Kenya is charged with the responsibility of the technical implementation of the ICT sector. This semi-autonomous body issues licences to ICT systems, manages the frequency spectrum and type and approves ICT equipment. The authority also protects the rights of ICT service consumers, ensure a level playing field for competitors, regulates tariffs, manages and administers universal service funds, in addition to ensuring compliance to licences and the law (CA, 2010). It also serves as Kenya's designated representative to local, regional and international ICT fora. It is important to note that due to rapid developments in technology, the traditional distinction between telecommunications, information technology (IT) and broadcasting has been blurred, thus making CA a converged regulator (KHRC, 2014).

Other institutions
There are a number of other institutions that are relevant to the management of the Kenyan ICT environment. These include: the appeals tribunal that arbitrates disputes between parties, the Directorate of e-Government founded in 2004, the Government Information Technology Services (GITS), which is under the Treasury; Kenya ICT Board (KICTB), whose role overlaps with that of the Directorate of e-Government. The Parliamentary Committee on Energy, Communications and Public World provides oversight on communication matters and the Monopolies and Prices Commission, which can make determinations on competition matters in the telecommunications business with respect to mergers and acquisitions (KHRC 2014; Waema and Ndungu, 2012,).

Kenya's ICT Policies and Regulations
Legislations guiding the Kenyan ICT sector include Kenya Information and Communications Act 2012 (1998), the Science and Technology Act, Cap. 250 of 2013 and the Kenya Broadcasting Corporation Cap 221 of 2012 (1988). In 2007, the government, through the Ministry of Information and Communication, formulated the National Information and Communication Policy which embraced diverse ICT issues. This policy was later reviewed in 2012 to mainstream issues in the country's blueprint, Vision 2030, the Kenya constitution 2010 and the dynamic and converging changes in the ICT sector (GOK, 2016). An overview of the legislative and policy environment of the ICT sector in Kenya is described below.

The Constitution of Kenya (2010)
The Constitution of Kenya, 2010 provides the legislative framework for diverse sectors of the economy and the country at large. The sections of the document having direct bearing on the ICT sector are: Article 6 (3) on equitable delivery of public services to Kenyan citizens everywhere; Article 11-2(a) on national and cultural expressions through science, communication, information and the mass media; Article 20 (2), which assures rights and freedoms to every person; and

Article 34, which provides for freedom of electronic and print media. Article 35 (1&2) grants access to rights of correct information held by the state or other persons, while Article 232 guarantees quality service delivery by the public service (GOK, 2010; 2014). These provisions have a bearing on how the information and communication sector is managed.

Vision 2030
Vision 2030, the country's long-term development blueprint, provides the framework that guides all sectors of the economy. The vision targets key sectors, including IT-enabled services, agriculture, livestock, tourism, trade, manufacturing, financial services, and energy. The vision recognizes that socioeconomic transformation is enabled by ICT, where wealth creation, social welfare, and international competitiveness are based on new knowledge emanating from science technology and innovation (STI). Utilization of existing and new knowledge, entrepreneurship, skilled population and dynamic information and communication infrastructure are some of the factors that are expected to drive the economy and institutions in the country.

The Science and Technology Act Cap 250 (2013)
Research in the information and communication sector is guided by the Science and Technology Act by virtue of infrastructure, while Science and Communication Science are scheduled sciences under Section 9(1). Conversely, the National Commission for Science, Technology, and Innovation (NACOSTI) regulates and assures the quality of scientific research and also advises the government on STI matters (STI Act 2013, GOK, 2012)

Kenya Information and Communication (KIC) Act (Cap 411A, 2012)
This Act was enacted by Parliament in 1999 when the ICT sector was at its infancy. Over time, however, various changes necessitated the amendment of the Act in 2011. This new Act mainstreamed relevant issues from the Kenya Constitution, 2010, such as fundamental rights and freedoms, human values and social justice. The Act also took cognizance of changes in technology, such as broadband capacity, interconnectivity, competition and innovation. Others included equitable access to electronic communications at affordable costs, open access that entails infrastructure sharing, among others. Additionally, the policy took into account competition, privacy and security, national and international standards and the use of ICTs to enhance achievement of Sustainable Development Goals (STI, 2013). A major landmark in the KIC Act is the legal recognition of electronic transactions (e-transactions) where e-records and e-messages were legalized for the formation of contracts and supported the use of electronic records and signatures in government and its agencies.

National ICT Sector Policy
The ICT policy was aimed at improving the livelihoods of Kenyans by ensuring the availability of accessible, efficient, reliable, affordable and secure ICT services; it has an overall objective of facilitating access to ICT services to all Kenyans. This is through enhancing the building of high-speed, new generation information technology infrastructure, developing a modern internet industrial system, implementing the national big data strategy and enhancing cybersecurity (GOK, 2016). The policy identifies nine key sectors as focus, including agriculture and rural

development and information communication technology (ICT) and spells out the roles to be played by different stakeholders in the policy implementation.

Regulations governing ICT in Kenya

In 2008, CCK introduced the Unified Licensing Framework (ULF) based on the principle of unified technology neutrality licensing to permit any form of communications infrastructure to be used to provide any type of communications service that an operator or service provider is capable of providing. This in effect dropped the multiple licensing regime, where services were grouped on the basis of services and technology. Consequently, ULF facilitated mobile operators to become the biggest providers of Internet services. ULF also led to the simplification of licensing procedure, development of new applications, increased internet penetration and increased infrastructure investment (Waema et al., 2010). About 12 oother regulations were released by the government in 2010 to significantly impact on the ICT stakeholders and govern the sector. These included: dispute resolution, tariffs, compliance enforcement, fair competition and equality, interconnection and provision of fixed lines, and universal access and service.

Of the 12 regulations, six are briefly elaborated as follows. The compliance, monitoring and enforcement regulation was meant to allow the communication authority inspect and enforce compliance to the licensed stipulation, while the consumer protection regulation was meant to protect consumers to enable them to opt in and out of the services. Conversely, the dispute resolution is meant to allow the authority resolve grievances between parties, where the two fail to reach an amicable resolution. The fair competition and equality of treatment provides for promotion of fair competition, equal treatment and protection against abuse of market powers or other anticompetitive practices in the communications sector. The tariffs regulation provides a framework for the determination of tariffs and tariff structures. The universal access and service component seeks to provide a regulatory framework for the design and implementation of universal access and service provision and for the administration of the Universal Service Fund in Kenya. Under the universal access is the Universal Service Levy charged on all licensees offering communications services on a commercial basis. The levy, pegged at 1% of the gross revenue of a licensee, is meant to support widespread access to ICT services, promote capacity building and innovation in ICT services in the country. A 2018 report by Thakur and Potter (2018) under the World Wide Web, Alliance for Affordable Internet and UN Women indicated that Kenya had a total of USD 42.01 million unspent USAF funds.

The tariffs and fair competition were appreciated by Telkom, Zain, and Essar but considered unfavourable by Safaricom, which led to the issuance of the competition guidelines by CCK. The tariffs and fair competition ensure that licensees maintain financial integrity and attract capital; protect interests of investors, consumers and other stakeholders; provide market incentives for licenses to operate efficiently; and promote fair competition. The fair competition regulation deals with the standards and procedures to be applied by the communications authority to determine anticompetitive conduct, and clarify conduct or practices that are prohibited under the Act and standards to apply when determining whether a telecommunication service provider is dominant in a given market

The Status of ICT Sector Markets and Funding in 2018

The rapid developments in the information and communication technologies sector has caused a convergence of services in the sector, thus blurring the differences between them. Thus, while broadcast services used to be clearly defined, the emergence of VoIPs led to an overlap of this service with data transmission. However, the CCK licensing structure has a schedule that classifies different types of licenses. The broadcasting market structure comprises the public and community, private and subscription broadcasting, signal distribution services and other licence classes that may be determined (CA, 2010). The fees for each of the licences vary with the service being targeted.

In 2017, the information and communication output increased by 10.9%. The short message service increased by 65.7%, domestic telephone calls increased to 44.1 billion, while international call tariff rose to 1,056.7 million minutes (GOK, 2018). The mobile subscription penetration rate per 100 inhabitants increased to 91.9%, while prepaid subscriptions increased by 88.9% and total mobile money transfers by 8.4% (GOK, 2018). These statistics are indicative of a highly viable economic sector that is growing exponentially. Most of this growth is out of disruptive innovations that render previous innovations redundant, with clear examples being the mobile money transfer that has rendered many previous money transfer services obsolete and digital newspapers that threaten the print media.

It is therefore imperative for the government to continually review its policies to embrace new developments that may eventually be of economic benefit to the country. To support all these developments, the government has actively funded infrastructure, such as the laying of the undersea cables TEAMS, SEACOM and EASSY jointly with selected private investors, and the National Fibre Optic Backbone Network connecting all counties.

The creation of i-hubs and other incubation centres in addition to the supporting policies all have contributed to the current ICT environment that has seen impressive growth. The government has proposed new projects, such as the Konza Technology City aimed at developing 500 new ICT companies and 20 global innovations and creating 50,000 jobs (GOK, 2014). By the end of 2017, not much development work was visible on the dusty expansive land, except for a half-constructed building launched two years before and expected to serve as the administrative headquarters of Konza Development Authority.

However, according to Parliament's Budget and Appropriation Committee Report (The Standard Newspaper, 4th March 2018), the situation changed positively during the 2018/19 budget, as Konza City received Ksh 2.4 billion, part of which was stripped from its allocation during the 2017/2018 supplementary budget. Out of the Ksh.2.4 billion, 1.6 billion was allocated to Konza Technopolis Development Authority, a parastatal charged with the development of the city. The city is attracting international investors. For instance, a financing agreement for Ksh 39 billion was signed between GOK and UniCredit SpA of Italy in August 2018 for Phase 1 infrastructure project (https://www.konzacity.go.ke). In February 2019, the Republic of South Korea partnered with Kenya's Ministry of Education to put up a graduate-only university in the Konza Technopolis. The institute, dubbed the Kenya Advanced Institute of Science and Technology (Kenya-KAIST), will be modelled after the Korean Advanced Institute of Science and Technology (Korea-KAIST). The design model is a research-focused university that will foster elite human resources in science and technology (https://www.konzacity.go.ke).

Other funding of the Kenyan ICT start-ups and talent is from non-Kenyan investors, called 'Angel-investors', who support start-up ideas and talents. Support is also through competitions, such as Pivot East, IPO48, Apps4Africa and Google Apps Developer Challenge. The competitions earn innovators between USD10,000 and USD25,000 and several top awards have been won by Kenyan innovators (Heike, 2016).

Conclusions and Way Forward

Kenya's ICT sector can be described as one that experienced turbulence at its formative stages but has, over time, reached early maturity and is fast heading to full maturity. A lot of the gains in the sector have arisen out of the bold step taken in 1998 to amend the Kenya Information and Communication Act, which paved the way for multiple players in the telecommunications sector. Although full liberalization was on several occasions spurned by the regulator, particularly during the five-year monopoly period and beyond (Waema *et al.,* 2010), this did not discourage the civil society organizations which maintained their quest for a fully liberalized sector. Eventually, the sector bowed to pressure from the stakeholders, the Vision 2030 blueprint, the Constitution of Kenya and developments in other parts of the World. It is important to note that the reforms in the communication sector could not have been easy without certain champions in the public and private sectors, such as individuals and civil society organizations: for example, the East African Internet Association, Kenya National ICT Forum, National e-Commerce Task Force, Telecommunication Dealers Association of Kenya and Computer Society of Kenya (KHRC, 2019). The opening of Kenya Open Data Initiative in 2011 was a significant milestone, as it was the first of its kind in sub-Saharan Africa and second only to Morocco in the continent. Since its launch, datasets, such as the Country Census, regional and national expenditure and other public services have been accessible to the public (Waema, 2017). Although the regulatory framework of the sector exists, there is more work to be done to keep abreast with the rapid changes, particularly the convergence or multi-functionality of ICTs that render certain regulations redundant within a short time. As illustrated by the amendments that have been done to existing acts and policies, it is hoped that potential amendments will be done in a timely manner to avoid being overtaken by emerging trends in the sector.

As a way forward, it is important to realize that an enabling ecosystem is mandatory if the developments in the ICT sector are to be sustained. Such an ecosystem comprises network operators, software developers, content providers, device manufacturers, government and users. It is also important to note that while the financial sector has grown by leaps and bounds, other sectors, such as agriculture and rural development, manufacturing and health have not registered such growth or gains. Therefore, there is need to focus on these sectors with a view to recording real GDP growth as a result of digitization of the service provision in these and other sectors. This will only be possible with the requisite enabling environment created by the government.

Status of Information and Communication Technology for Agricultural (ICT4AG) Services
Introduction

A large body of theoretical and empirical literature assert that ICT plays a critical role in agricultural sector, especially in the provision of services (Chavula, 2014). Likewise, the research attention given to ICT in agriculture is a testament to its potential role and impact on improving agricultural productivity, economic growth and poverty reduction (Asiedu-Darko & Bekoe, 2014). In many countries, different traditional channels, such as radio, have been used to communicate important messages to farmers. However, the introduction of internet, mobile technology and social media has transformed the way information is being used and communicated with farmers. Although globally, agricultural sector has been lagging behind in digitization (McKinsey report, 2019), Kenya is among the top rated digital ecosystems in sub-Saharan Africa (SSA) (World Bank, 2016). Further, it is ranked second on enabling digitalization index and digital evolution index by the Harvard Business Review (HBR) of 2017 (https://sites.tufts.edu). Also Kenya was ranked fourth in digital adoption index by World Bank 2016 Report (World Bank, 2016).

Consequently, mobile applications (M-apps or M-services) have introduced new ways of delivering contents and functions in diverse sectors of the economy, including agriculture in both developed and developing countries (World Bank, 2012; Syngenta Foundation, 2012; Heike, 2016). This development has a potential to revolutionize extension service delivery in the agriculture sector through timely delivery of information on productivity-enhancing techniques, financial and other services (World Bank, 2012; Syngenta Foundation, 2012). This process is being facilitated by recent improvements in ICT infrastructure that have led to mobile phones being used efficiently to transmit voice, data and other services (World Bank, 2012; Duncombe, 2012). Advantages of mobile phones include affordable costs, extensive ownership, voice communications, and instant and convenient service delivery. Bhatanager and Shcware (2000) and Aker (2011) indicated that information and communication technology (ICT) systems have opened new opportunities for addressing rural poverty, inequality, agricultural techniques and other issues.

The level of annual household input was found to increase to $42, while a 37% increase in household agricultural commercialization was recorded per annum (Kauri *et al.,* 2012). Another study by the World Bank (2012) found a 9% ($300) average income growth by tea growers in Kenya through production measuring, recording, and traceability functions of the virtual city, Agri-Manager app.

The recent expansion in mobile networks, coupled with reduced handset prices and multi-functionality, has led to an explosion in m-apps with a major challenge being the rapid turnover of innovative products and the competition for market share by mobile network operators (World Bank, 2012). In a 2015 study, it was concluded that countries are yet to realize the full potential of the many m-apps and that developers should cater for a broad range of users (Heike, 2016). Consequently, studies in a number of countries have been conducted to understand the use of m-apps in agricultural services delivery.

In a quest to assess the status of information and communication technologies for agricultural development (IAR4D) in Kenya, a survey was conducted in Nairobi County and its environs. A total of 72 ICT4AD were identified and, using their service functions, grouped into six broad clusters (Figure 12).
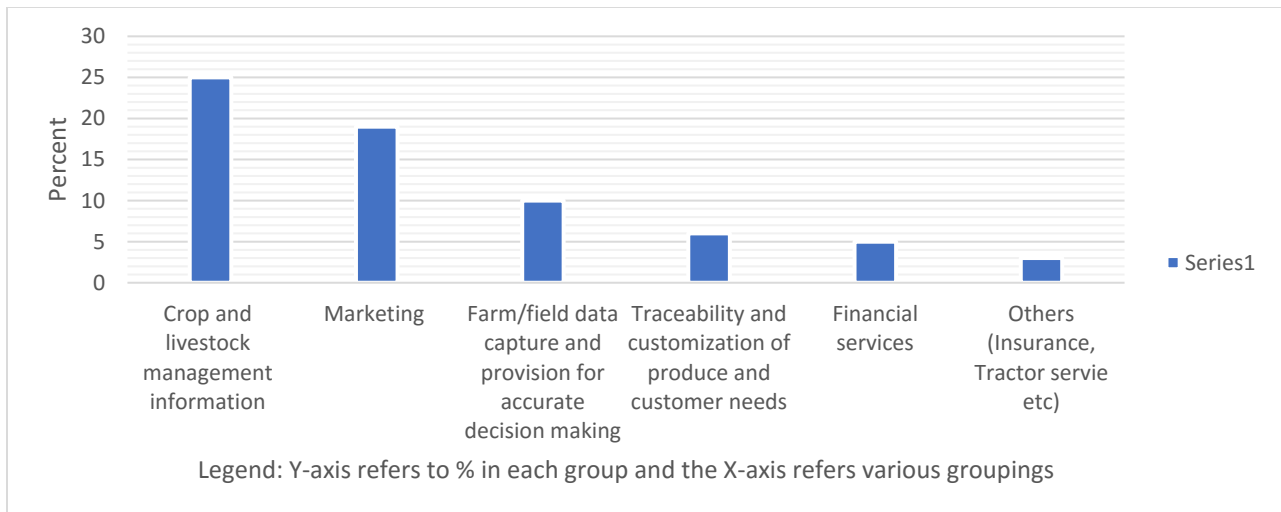
Figure 12: ICT4Ag service provider clusters
(Source: ICT4Ag survey 2019)

The most common (64% of) apps were on crop and livestock management and marketing. These two clusters provided information to farmers, in conformity with the World Bank (2016) study that most apps were on information provision due to asymmetrical information access in rural areas of developing countries. The least number of apps (20%) were on traceability, financial services and others. Field data-captured apps were 14%, a cluster that depicts a combination of sensors and m-apps and provides an example of Internet of Things (IOT). A discussion of the characteristics of each of these clusters is provided below.

Crop and Livestock Management Information Providers
The crop and livestock category comprised 25 service providers (Appendix I), which were at different stages of deployment, ranging from pilot and advanced stages. Six were at early and advanced deployment stages, while the statuses of 10 were unknown. As reported by Heike (2016) and World Bank (2012), providers in their pilot phases can transit to full scale businesses; hence, their effectiveness may prove difficult to assess. Fourteen provided information on crop and livestock, four on dairy and the rest on crop health, agribusiness, horticultural crops and agro input supplies, targeting smallholder farmers, students, extension officers and traders along value chains. The content mix of these providers is an indication of the diverse demands that need to be addressed by the ICT4Ag providers; although, it is for the developers to include other contents that may be required by the users.

Multiple media (including mobile phones, radio, web portals and television) were used to gather and disseminate information. The majority of the service providers did not charge any fee except Smartcow that charged for telephone calls and a modest subscription fee. As stated in the report by World Bank (2012), the lack of a business approach made it difficult for an assessment of business models of non-commercial m-apps. Since the business models of the apps were not

assessed, it is difficult to conclude that business orientation was the reason for the charge by the three providers.

All the service providers except Pride Africa had URLs that targeted smallholder farmers. To disseminate information, they used web-based tools, SMS and telephone calls with scanty information on cost to users and their revenue models. However, KTDA charged for bulk SMS at Ksh. 2,000 while the Agriculture and Food Authority (AFA) disseminated its products without charging.

While a majority of the ICT4Ag service providers did not avail information on the deployment status of their technologies, AFA, M-Shamba Limited and Mediae Company were at an advanced deployment stage, indicating that their solutions were working effectively. They offered information on good agronomic practices, where to buy inputs and sell their produce, and financial services. TruTrade offered online and mobile-enabled trading and payment platform for collaborative supply chain management that allows for the capture of all costs, analysis of transaction viability and price setting; registration of farmers and triggering payments; and tracking of produce from collection to delivery points.

Only one service provider that increased traceability of inputs (such as seed, fertilizer, chemicals) was captured. Increased traceability would establish genuine products and genuine service providers from counterfeit ones. The presence of counterfeit products on the market is a problem that is on the increase in the agricultural sector and needs to be curbed. In addition, the inventory did not identify apps for consumers, who need to increase traceability of consumer goods. However, traceability can only work in an organized system, where all products are registered with an organized body for reference. This is one area (traceability) that service providers should develop for the agricultural sector. This could be through an app, like the use of SMS short code by the Pharmacy and Poisons Board of Kenya (PPBK) to weed out illegal pharmacies/chemists that endanger the lives of the public (https://pharmacyboardkenya.org). KEPHIS had a short code for tracing whether an input dealer was licensed; but it was difficult to trace input movement from the factory to the farm (Syngenta, 2012). Moreover, there was opportunity for service providers to develop apps on diagnosis of pests and diseases.

Marketing

There were 19 marketing service providers which mainly provided market, consumer and production information and linkages, with some targeting the entire value chain (Appendix II). However, some included services, such as automated record keeping, facilitating access to inputs and provision of traceability codes for quality assurance. Most of the service providers were specialized, linking farmers to traders, vendors and buyers. The Eastern Africa Grain Council (EAGC) provided services in warehousing and linkages between farmers, banks and warehouse owners. They used either mobile interface, laptop/desktop screen or a combination of data gathering and analytics. The Kenya Agricultural Commodity Exchange (KACE) service provider used voice, mobile interface, laptop/desktop screen for data gathering and analytics, while Farm IT had none reported. For dissemination, they used web based applications and mobile telephones.

On status of deployment by service providers, three were at an advanced state, three at the development stage and the development status of four was unknown. The specified costs to

users by service providers included: Premiums (KSh 500 per annum), cost to acquire certificates for warehouses and a percentage of the fee incurred for the transaction and deduction of charges incurred at the warehouse and SMS charges; eight providers did not indicate how costs were apportioned to users. The World Bank (2016) identified four pricing models, viz: non-chargeable, transaction-based, embedded services and premium model, and stated that there may be overlaps in their deployment. KACE and KTDA used the transaction-based model, in which charges are based on a number of transactions. Funding/revenue generation model provided by service providers included: money received from messaging system, trading and transformation (processing) firms, NGOs pays on behalf of farmers and warehousing, while Sokopepe Limited services received from clients premiums (KSh 500 per annum) and the Kenya Market Trust services were donor funded. It is worth noting that in majority of the services, there was always a cost for the SMS received but a good proportion of the payment went to the provider.

Farm/Field Data Capture and Provision for Accurate Decision Making
There were 13 service providers involved in the capture and provision of information that enabled accurate decision making at the farm and/ or field level (Appendix I). The data provided were mainly on weather and agronomy and alerts on pests and diseases; their targets were farmers and other value chain actors. The commonest ICT tool used for both data collection and dissemination was the mobile interface; six service providers also used the laptop/desktop. Two of the service providers used remote sensing, new in-situ sensors and satellite-based geo-data, to provide tailored technology-based agriculture solutions by giving information on weather and water, reducing risks and challenges in agriculture. One service provider combined smart applications with the nutrient scanner to get on-the-spot insight into soil fertility. The devices and applications (IOT) were based on cutting edge data solutions after a rapid soil analysis.

Financial Services
There were nine (9) financial service providers targeting small and medium-scale farmers, which had contact points and URL. There were two other specialized services on insurance (Appendix I). The other services provided were input financing, marketing, crop failure and livestock insurance; access to extension providers, produce buyers, financiers and credit providers, and a platform on cashless transactions. Musoni Microfinance specialized in production services, while five financial service providers targeted the entire value chain using mobile interface for data gathering and analytics and laptops/desktops. They used mobile applications, including SMS, USSD Codes (*225# and *492#) and web-based ICTs for dissemination. The status of deployment for five service providers was rated as advanced deployment. The cost to users for two of the service providers was derived from farmers; groups paid fees upfront and/or interest on loans. One service provider entirely charged a fee on loan (6% of amount borrowed). Four out of nine providers had a funding/revenue generation model based on interests on loans, while one had a price based on type of service and four did not have any known model.

Traceability and customization of produce and needs
A total of seven (7) ICT4Ag providers availed the research team integrated services and information. Three of the providers (Ashley King, KTDA and Bonded Groceries) facilitated

traceability of farm produce along the value chain. Ashley King facilitated the creation of global food and farm produce traceability, while KTDA, through Virtual City App, provided traceability of produce, transport, processing and marketing services to tea farmers. A total of 565,000 tea farmers were served, with such benefits as reduced transaction time at buying centres, a 9% increase in income, and a 75% reduction in cost of delivery, among others (World Bank, 2012). Bonded Groceries provided consumers interface and assigned traceability codes to products sold in local and international markets. BoP innovation Centre supported farmers to produce, transform and supply food products to local, regional and national markets, while Apollo used satellite images to customize farmers' credit risk. Mara Farming Group of Companies focused on the need to produce, package and market fresh vegetables and fruits to suit individual client preferences.

Others (Insurance and Tractor hire services)
Two of the remaining three ICT4Ag providers dealt with insurance products. Acre Africa developed agricultural insurance products for insurance companies on seed replanting guarantee, weather index cover, hybrid index and multi-peril crop insurance (MPCI) and livestock cover. Kenya Commercial Bank and Master Card Foundation helped farmers to get input finance, to save, obtain insurance and market their produce through a mobile phone bank. Considering the phenomenal growth of the mobile money transfer service in Kenya, there is the need to explore the possibility of popularising financial services through ICT4Ag providers. A possible approach would be to combine it with other services or customise it to a client's or a group of clients' preferences. As Heike (2016) stated, farmers face a multitude of problems besides technological challenges; hence, developers have to provide m-apps with complementary services, which could be paid for by other actors.

Finally, an Uber-type mobile app, referred to as e-Tinga (Swahili for tractor) was launched by Quipbank Trust Ltd in 2017 to help farmers book their preferred tractor services at a click of a button and track it right to their farms. Ten hubs or offices have so far been opened in various parts of the country, with the head office in Naivasha. For a farmer to access e-Tinga services, he would download the app from Google Play Store and provide his telephone contact and location. Then, he would send the word TINGA to a short code (22150) which is a free SMS service. The app is equipped with GPS antennae to collect real-time information in remote areas and keep track of all clients. The service is charged at Ksh 2,500 per acre for ploughing or harrowing (www.hortinews.co.ke). This is an area that can be explored further, considering the drudgery that characterises farming operations in Kenya. But there is also the need to consider the farm sizes and provide small machinery that would be fit for these sizes.

Conclusion and Way Forward
The study has established that the government of Kenya and the private sector have invested in ICT, especially in provision of required infrastructure. To build the ICT sector, one of the key requirements is to attract foreign flows in a structured manner with clearly defined exit routes for investment that ultimately move ownership from foreign to local entities. When network was difficult to establish through the private sector due to low profitability and remoteness, the government with support of the Chinese government developed the National Fibre Optic

Backbone Initiative (NOFBI). Various legislative and policy instruments have been put into operation to provide a conducive environment for stakeholders. These instruments include the Kenya Information and Communication Act, 2008, and the National ICT policy 2016. The policy and legal environment has attracted a sizeable number of reputable international players in the ICT sector. These players have subsequently supported and enhanced innovation in the sector. However, this growth and innovation have been below expectation in the agricultural sector due to the absence of specific policy, legal and institutional frameworks in support of agricultural peculiarities. The development of ISTGS was a good starting point. On access to ICT services, information on handsets was readily available; although, there was limited information on household SIM card ownership vis-à-vis handset ownership and usage.

ICT is recognized as a major enabler of national and sectoral policies and strategies. A robust institutional and legal framework has been established to support the growth of the ICT sector, despite the existing teething problems. It is apparent that among all the service providers, only two service providers targeted the youth; a category that needs to be encouraged and supported to engage them in agriculture for increased income. The inventory of ICT services showed a significant increase in service providers in the last 10 years. The major target users of ICT services were farmers. The inventory also showed room for growth in the sector, as only a few providers were at an advanced stage of development. Many ICT service providers in the inventory had mobile interfaces, which is quite encouraging because of farmers' excellent access to smart phones. In addition, SMS was their most effective method of disseminating information; perhaps because of its immediate, real-time feedback.

Based on these conclusions, the following recommendations are made:

1. The agricultural market for ICT services and products is still developing and agriculture remains a conservative industry. The government will need to subcontract work to the 'locals' to enhance job creation. Examples include, but not limited to, technology opportunities that take the 30% ICT government procurement proposal and scale these to millions of Kenyans.

2. Moreover, the youth should be encouraged and supported to develop apps as a way of encouraging them to engage in agriculture and enable them earn money from it.

3. The Kenya government should provide incentives to the private sector to broaden its services especially in the ICT for agriculture subsector to spur innovation in service provision;

4. There is the urgent need to develop a robust policy and institutional framework for agriculture ICT to spur growth and innovation;

5. Crop and livestock information dominated the 22-item list of service providers, perhaps due to the importance or demand for this information. There was also limited targeting of the services provided and no clear quality assurance on the contents. Therefore, there is need for policy and legal framework to ensure quality assurance, compliance and accountability.

6. There were many models of financing to provide a level playing field for all investors in the ICT ecosystem; but these were not standardized in the sector. There is therefore the need to standardize models of financing ICT services.

7. There was no information on digital literacy, hence the need to undertake a study that will inform areas for capacity building and levels of complexity/simplicity of the various infrastructure for information provision.

8. There is a need to conduct more in-depth study on ICT service providers in Kenya, as most aspects, such as cost to end users and funding, were still largely unknown. These aspects are particularly important because they determine the uses of the services.

References

African Development Bank Silicon Kenya (2016) Harnessing ICT Innovations for Economic Development.

Aker, J. C. (2011). Dial "A" for agriculture: a review of information and communication technologies for agricultural extension in developing countries

Ali, J (2011). Use of quality information for decision-making among livestock farmers: Role of Information and communication technology. Livestock Research for Rural Development 23 (3).

Anderson, M. (2015): Kenya's tech entrepreneurs shun Konza 'silicon savannah'. The Guardian. Available online at https://www.theguardian.com/global-development/2015/jan/05/kenya-technology-entrepreneurs-konza-silicon-savannah

Asiedu-Darko, E., and Bekoe, S. (2014). ICTs as Enabler in the Dissemination of Agricultural Technologies: A Study in the East Akim District, Eastern Ghana. Asian Journal of Agricultural Extension, Economics & Sociology, 3(3), 224-232.

Bhatnagar, S and R. Schware, Eds, (2000). Information and Communication Technology in Rural Development. Case Studies from India, World Bank Institute Working Papers, (2000).

CA. (2014). Sector Regulations (https://ca.go.ke/about-us/statutes-regulations/sector-regulations/).

CCK (2007) Internet market analysis report –By Netcom Info. Systems Ltd

CCK Strategic Plan (2008-2013). Communications Commission of Kenya (CCK), 2008.

Chavula, H. K. (2014). The role of ICTs in agricultural production in Africa. Journal of Development and Agricultural Economics, 6(7), 279-289.

Chirchietti, N. and Freitag, S. (2016). The role of Innovation Hubs taking startups from idea to business: The case of Nairobi, Kenya. BONN-RHEIN-SIEG UNIVERSITY OF APPLIED SCIENCES. MSc Thesis

Communication Authority of Kenya (CAK). 2018. First Quarter Sector Statistics Report for the Financial Year 2018/2019 (July-September, 2018), Nairobi Kenya.

Communications Authority Website – (https://ca.go.ke/)

Communications Authority (2019) Quarterly report 2019

Consultoria A., (2011). Study on ICT Access Gaps in Kenya: Final Report", prepared for the Communications Commission of Kenya (CCK).

De Bastion, G. (2013): Technology Hubs. Creating space for change: Africa's technology innovation hubs. Edited by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Bonn. Available online at https://10innovations.alumniportal.com/fileadmin/10innovations/dokumente/GIZ10innovations-01_Technology-Hubs-Brochure.pdf

Duncombe, R (2012) Mobile applications for agriculture and rural development: A literature review and future research directions: Working paper series No 50 Center for Development Informatics ISBN: 978-1-905469-31-4

Friederici, N. (2015b): Hubs vs Incubators what are the pain points for impact and efficiency. Available online at http://cii.oii.ox.ac.uk/2015/12/28/hubs-vs-incubators-what-are-the-pain-points-for-impact-and-efficiency/

Gathege, D.; Moraa, H. (2013): Draft Report on Comparative Study on Innovation Hubs across Africa. Edited by iHub Research. Available online at http://research.ihub.co.ke/uploads /2013/may /1367840837   923.pdf

Gathege, D.; Moraa, H. (2013): ICT Hubs model: Understanding the Key Factors of the iHub Model, Nairobi Kenya. Edited by iHub Research. Available online at http://research.ihub.co.ke/uploads/2013/may/1367834943   374.pdf

GoK, (2015). The Kenya Information and Communications Act, CAP 411A. Revised Edition 2015 [2012].

GoK, (2014). The Kenya National ICT Master plan 2014-2017: Towards a smarter Kenya

GoK, (2019). Kenya's Agricultural Sector Transformation and Growth Strategy 2019—2029

GoK (1978). Kenya Posts and Telecommunications Corporation Act Cap 411, 1978

GoK (1998). The Kenya Information and Communications Act (Cap 411)

GoK (2004). e-government strategy

GoK (2007). Kenya Vision 2030.

GoK (2008). First Medium Term Plan, 2008 – 2012

GoK (2009). The Kenya Communications (Amendment) Act of 2009. Kenya Laws

GoK (2010). Constitution of Kenya

GoK (2012). A policy framework for science, technology, and innovation: Revitalizing science, technology and innovation in Kenya

GoK (2012a). National Agricultural Sector Extension Policy (NASEP), June 2012.

GoK (2012b). National Agribusiness Strategy. Making Kenya's agribusiness sector a competitive driver of growth. June 2012. The Kenya Constitution 2010

GoK (2013). The Kenya Information and Communications (amendment) act, 2013 (no. 41a of 2013)

GoK (2013b). Science, Technology and Innovation (STI) Act, No. 28

GoK (2013c). Executive Order No.2 of 2013 on the Reorganization of Government

GoK (2013e). The Media Council of Kenya (MCK) Act 2013. Kenya Laws.

GoK (2014). Vision 2030 Flagship Projects Progress Report November 2014

GoK (2016). The National Information and Communication Policy

GoK (2017). Kenya Youth in Agribusiness Strategy 2017-2021. April, 2017

GoK (2018). Kenya-Vision 2030 Sector Progress Project-Report, June-2018. http://vision2030.go.ke/inc/uploads/2018/09/Kenya-Vision-2030-Sector-Progress-Project-Updates-June-2018

GoK (2018). National Broadband Strategy 2018-2023

GoK (2018). Third Medium Term Plan 2018 – 2022. Transforming Lives: Advancing socio-economic development through the "Big Four".

GoK (2019). National Economic Survey Report

GoK 1998. The Kenya Information and Communications Act 1998. Kenya Laws.

GoK, (2008). Communications Commission of Kenya (CCK) Strategic Plan, 2008-2013.

GoK, (2013a). Second Medium Term Plan, 2013 – 2017 Transforming Kenya: Pathway to Devolution, Socio-Economic Development, Equity and National Unity.

GoK, (2013d). The Kenya Information and Communication (Amendment) Act 2013. Kenya Laws.

GSMA (2014). Digital Entrepreneurship in Kenya, available at:

Heike, Baumuller (2016). Agricultural service delivery through mobile phones: Local Innovation and Technological Opportunities in Kenya. In Franz W. Gatzweiler, Joachim von Braun (Eds) Technological and Institutional Innovations for Marginalized Smallholders in Agricultural Development (ISBN 978-3-319-25718-1 (eBook)

Honjo, Y. (2000). Business failure of new firms: an empirical analysis using a multiplicative hazards model. In International Journal of Industrial Organization.

http:// www.itu.int/ict

http://kplc.co.ke/content/item/35/kenya-power-fibre-optic-network

http://www.gsmaentrepreneurshipkenya.com/

https://founder360mag.com/7-agri-tech-startups-disrupting-small-scale-farming-in-kenya/)

https://legibra.com/digital-literacy-in-kenya/ - Digital Literacy in Kenya: Digital Service Providers have a role to play.

https://sites.tufts.edu/digitalplanet/files/2017/03/Digital-Planet-Executive-Summary.pdf

https://www.hortinews.co.ke/2017/02/14/new-app-enabling-farmers-access-tractor-services-with-ease-2/

https://www.konzacity.go.ke/news/kenya-to-establish-the-science-and-innovation-centered-university-at-konza-technopolis/).

https://www.konzacity.go.ke/news/konza-takes-off-with-kes-39-billion-infrastructure-project-commencement/).

ICT Authority (Ed.) (2014): The Kenya National ICT Masterplan. Towards a Digital Kenya. Available online at http://www.icta.go.ke/national-ict-masterplan/, checked on 5/30/2019.

ICTA, (2013). Information Communication and Technology Authority (ICTA) Strategic Plan 2013 – 2018

Ivy Drafor (2016) Access to Information for Farm-Level Decision-Making, Journal of Agricultural & Food Information, 17:4, 230 -45

JUMIA (2018) Kenya Mobile White Paper 2018: Smartphones: The gateway to a better life. https://jumia.co/nl-templates-kenya/uploads/mobilereport/ Jumia_MW18_White_Paper.pdf

KALRO (2018). Kenya launches 14 mobile apps to transform agriculture, June 2018. https://www.scidev.net/sub-saharan-africa/agriculture/news/kenya-mobile-apps-transform-agriculture.html

Kelly, T. and Firestone, R. (2016). How Tech Hubs are helping to Drive Economic Growth in Africa. Background Paper for the World Development Report 2016

KENET, (2011). The KENET Strategic Plan. 2011-2015

KENIA, (2018). Ecodudu: Quality Animal Feed and Soil Conditioner. October, 2018. http://www.innovationagency.go.ke/index.php/2018/10/15/ecodudu/

KENIA, (2018). Ujuzi Kilimo soil kit. http://www.innovationagency.go.ke/index.php/2018/10/15/ujuzi-kilimo-soil-kit/

Kenya Internet Stats and Telecommunications Report https://www.internetworldstats.com/af/ke.htm.

Kenya Mobile White Paper (2010), *https://www.jumia.co.ke/mobile-report/*

KEPSA and GoK, (2017). AJIRA Digital Project: Inspiring a New Era. April, 2017

KHCRRC, (2014). The Internet Legislative and Policy Environment in Kenya. January 2014

KHRC (2014) The Internet Legislative and policy environment in Kenya ISBN: 9966-941-84-3.

Kirui O.K.; Okello J.J.; Nyikal RA. (2012) "Impact of Mobile Phone-based Money Transfer Services in Agriculture: Evidence from Kenya."; (University of Nairobi)

KNBS, (2018). Basic Report: 2015/2016 Kenya Integrated Household Budget Survey, Nairobi, Kenya. ISBN:978-9966-102-03-4

KNBS. (2011). National ICT Survey Report. Nairobi, Kenya.

Law, Nancy; Woo David, de la Torre Jimmy and Wong Gary (2018) Centre for Information Technology in Education (CITE), University of Hong Kong. A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2. Information Paper No. 51 June 2018 UIS/2018/ICT/IP/51

MCSC and CMEDT, (2015). Elimsis (an ICT-based platform). https://www.f6s.com/elimsis

MICT, (2013). Strategic Plan 2013-17

MICT, (2014). National ICT Master Plan 2017. Nairobi April 2014

Msimang M., (2011). Broadband in Kenya. Built it and they will come. Information for Development Programme. World Bank and International Development Corporation (IFC)

Mthuli N. and Ondiege, P. (2016). How Tech Hubs are helping to Drive Economic Growth in Africa. Background Paper for the World Development Report 2016: Digital Dividends

Mureithi, M (2017). The internet journey for Kenya: The interplay of disruptive innovation and entrepreneurship in fuelling rapid growth- in Digital Kenya Ndemo, B and Weiss, T (Eds)

Ndemo, B (2015). Effective innovation policies for development – in The Global Innovation Index 2015 Chapter 9.

NIAB, (2016). Agri-Transfer: Farmer-managed trials and demonstrations Progress update - April 2016

Njenga, J. M. (2018). Continuous improvement and operational excellence among internet service providers in Kenya.

Nxele, M and Arun, T (2005). Regulatory impact on the development of the telecommunications sector in East Africa: A case study of Kenya – Centre on regulation and competition working paper series – Working Paper 99 ISBN: 1-904056-98-9 - Institute for Development Policy and Management, University of Manchester.

Pharmacy and Poisons Board of Kenya (2019) Kenya can identify legitimate pharmacies through SMS (https://pharmacyboardkenya.org/pharmacies-crackdown (accessed 30th May 2019)

Pradhan, R. P., Mallik, G., and Bagchi, T. P. (2018). Information communication technology (ICT) infrastructure and economic growth: A causality evinced by cross-country panel data. IIMB Management Review, 30(1), 91-103.

Prashant Gandhi, Somesh Khanna and Sree Ramaswamy of McKinsey Global Institute (Jan, 2019). Which Industries are the Most Digital (and Why)? Harvard Business Review, April 2016. *https://hbr.org/2016/04/a-chart-that-shows-which-industries-are-the-most-digitaland-*

Souter, D, and Kerrets, Makau (2012) Internet governance in Kenya: An assessment for the internet society – ICT development associates Ltd

Standard Newspaper (2018) MPs breathe Sh2.4b life into Konza City dream. Parliament's Budget and Appropriation Committee Report (The Standard Newspaper, 4th March 2018),

Sutherland, E. (2014). Undersea cables and landing stations around Africa: Policy and regulatory issues.

Syngenta Foundation (2012). m-agriculture: Mobile Applications in Agriculture

Thakur, D. and Potter, L. (2018). Universal Service and Access Funds: An Untapped Resource to Close the Gender Digital Divide. Washington DC: Web Foundation.

UNCTAD (2015). Trade and Development Report

Waema, T., Adeya, C., and Ndung'u, M. (2010). Kenya ICT Sector Performance review 2009/2010: Towards Evidence-based ICT Policy and Regulation Volume Two, Policy Paper 10, 2010. Research ICT Africa .net

Waema, T.M (2005). A Brief History of ICT policy-making in Kenya at the crossroads: ICT policy-making in East Africa Eds Etta, F, and Elder, L.

Waema, T.M, and Ndungu, M (2012). What is happening in ICT in Kenya? A supply and demand side analysis of the ICT sector – Evidence for ICT Policy Action Policy Paper 9-2012

World Bank (2012). Information and Communications for Development Report

World Bank (2016). Development report

World Bank 2010. Kenya Economic Update

ANNEXES

ANNEX 1: The 68 ICT4Ag Service Providers

Name of Service	Provider/ Operator	Start Date	Functions of the Service	Target users	Value chain stage(s)	ICT used for data gathering and analytics	ICTs used for dissemination	Status of deployment	Cost to users	Funding / revenue generation model	Contact point and URL
			Broad categories (e.g. access to input or output markets, supply chain management, data collection, information provision, financial services etc.) **AND** further details about the functions	e.g. farmers, traders, input providers, processors, exporters, logistics companies etc.	1. R&D 2. Input provision 3. Production (growing, harvesting, post-harvest handling) 4. Transformation (classification, processing, packing) 5. Trade (transport, distribution, sale) Consumption 6. Other (please specify) 7. Not applicable	e.g. GPS, satellites, sensors, RFID tags, camera, voice recorder, mobile interface etc.	e.g. SMS, USSD, call centre, IVR, smartphone app, webpage	1. Development 2. Early deployment 3. Advanced deployment 4. Unknown			
KALRO Mobile Applications and digital platforms	Kenya Agricultural and Livestock Research organization	Unknown	• Developing, customizing and operationalizing e-platforms for GAPs, marketing & weather advisory services • Training potential agricultural value chain stakeholders to effectively and sustainably use the platforms • Improving and enhancing access to agricultural information through digital technology	All value chain actors in all counties and other regional countries	All value stages from production to consumption	Mobile interface, Monitor/Laptop screens, Published papers and Voice	Wide web(WWW) portals, Mobile applications Radios Tvs e-bulletins	Advanced deployment	Free of charge	Donor funded and no business model available	Website: www.kalro.org Boniface Akuku Boniface.Akuku@kalro.org Lawrence Mose Lawrence.Mose@kalro.org Simon Mulwa Simon.Mulwa@kalro.org
aWhere/Esoko /eProd	aWhere company	1999	Provides farmers with weather, climate and agronomic recommendations, alerts on pests and weather using satellite data	Research organizations, traders, policy makers and farmers	Input provision and Production	Mobile interface, Monitor/ Laptop screens	Website	Advanced deployment	Subscription is 50,000 US dollars per user	Business enterprise	Website: www.awhere.com

Easyway	Octagon Data Systems Limited	Unknown	Provides field data capture where production takes place	Producers, employees and business partners	Input provision, Production, Transformation (Processing), Storage and logistics, Distribution and trade, and Consumption	Mobile interface	Android Mobile App	Advanced deployment	Unknown	Unknown	Website: http://octagon.co.ke/site/parent-slider/easyway-erp-utility-business-suite/ Phone: +254 713 857 260
Farm Radio International (FRI)	Farm Radio International	Unknown	Provides sharing voice messages on radio to smallholder farmers organized in radio groups or as individuals in their own homesteads	Small holder farmers	Input provision, Production, Storage and logistics, Transformation (Processing), Distribution and trade, Customer/consumption	Voice	Voice messages on radio, Mobile phone calls	Advanced deployment	Unknown	Unknown	Website: http://www.farmradio.org
eGranary	Eastern Africa Farmers Federation (EAFF) and Mobile Decisioning Africa Limited (MO-DE)	Jul-16	Aggregates farmers for easier access to markets, financial services and extension support.	Grain Farmers and buyers	Input provision, Production, Transformation (Processing), and Storage and logistics	Mobile interface	USSD Code *492#	Advanced deployment	Unknown	Unknown	Web: http://www.eaffu.org Tuyishime Norbert norbert.tuyishime@gmail.com info@eaffu.org Tel: +254-20-4451691
EPIC Learning Content	Ycenter Inc. of Philadelphia, USA, together with P4ACAD	Unknown	Captures mentors' knowledge and matches questions that students or farmers ask with the knowledge and provides responses intelligently matched with the questions.	Unknown	Input provision, Production, Storage and logistics, Transformation (Processing), Distribution and trade and Consumer/customer support	Unknown	Unknown	Pilot Testing	Unknown	Unknown	Unknown

FARMIS	Sokopepe Limited	2014	Automates farmer record keeping, provides market information throughout major markets in Kenya, uses farmer income records for credit scoring, facilitates access to inputs and linkages to markets, and provides agronomy tips.	Farmers	Input provision, Production, , Distribution and trade	Mobile interface, Laptop/Desktop screen	Web application	Advanced deployment	Paying for Premiums (KSh 500 per annum	Money earned from the Premiums	Website: http://www.farmis.co.ke/
HIVOS/P4ACAD GALS	HIVOS, Programme for Agricultural Capacity Development in Africa supported by CTA and GODAN	Unknown	It is promoting the convergence of university and (technical vocation education and training) TVET students offering services to smallholder farmers organized in value chain-driven commodity agribusinesses	Universities, TVET students and small holder farmers	Input provision, Production, Storage and logistics, Transformation (Processing), Distribution and trade and Consumer/customer support	Unknown	Unknown	Unknown	Unknown	Unknown	Richard Kaguamba
iCow	Green Dreams Tech Ltd	Unknown	Connects farmers to agricultural sectoral actors as well as supporting them address livestock and crop production challenges.	Dairy Farmers	Production	Mobile interface	Mobile Phone app and USSD *285# and SMS	Unknown	Unknown	Unknown	Website: http://www.icow.co.ke/ Email: info@icow.co.ke
InfoNET Biovision	Biovision Africa Trust (BvAT)	Unknown	Gives farmers, trainers, students, and extension workers quick access to up-to-date and locally relevant agricultural information and related topics	Farmers, students and extension workers	Input provision, Production	Mobile interface, Laptop/Desktop screen	Online (Web)	Advanced deployment	Unknown	Unknown	Website: http://www.infonet-biovision.org/ Hudson Shiraku Were hshiraku@biovisionafrica.org Tel: +254 (0)719 05 2195
iShamba	The Mediae Company	Unknown	It is a call center that provides agricultural expertise to those seeking agricultural information including where to sell produce	Crops and livestock farmers	Input provision, Production, Storage and logistics, Transformation (Processing), Distribution and trade, Customer/consumption	Mobile interface, Voice	SMS code 21606 and Phone Calls	Advanced deployment	Signing users to premiums (KSh. 899 per annum)	Money collected from the premiums	Website: https://ishamba.com/ Tel: +254 711 082 606 Email: ishamba@mediae.org

Juhudi Kilimo	Acumen Fund, Soros Economic Development Fund and the Grameen Foundation (USA)	2011	It offers market-driven and wealth-creating financial services that empower smallholder farmers and other value chain actors in order to create sustainable agribusinesses and improve their livelihoods.	All value chains actors	Input provision, Production, Storage and logistics, Transformation (Processing), Distribution and trade, Customer/consumption	Laptop/De sktop screens	Social micro-finance institution	Development	Unknown	Unknown	Website: https://juhudikilimo.com/ John Muthee muthee@acumenea.com
LandInfo Mobile App	African Technology Policy Studies Network (ATPS)	Unknown	Allows users to make decisions on the potential of their land in crop production, soil types and soil erosion risk, and supports decision making on sustainable land management practices.	Farmers in areas prone to soil erosion	Input provision and Production	Mobile interface	Mobile application	Development	Unknown	Unknown	Website: http://www.ict4ras.org/landinfo-mobile-app/
LandPKS	Regional Centre for Mapping of Resources for Development's (RCMRD)	Unknown	Allows users to make decisions on the suitability of their land for crop production, the soil types and soil erosion risks, and supports decision making on sustainable land management practices.	Farmers in areas prone to soil erosion	Input provision and Production	Mobile interface	Mobile app	Early development	Unknown	Unknown	Website: https://landpotential.org/
MobiGrow	Kenya Commercial Bank (KCB) and MasterCard Foundation	Unknown	Help farmer get input finance, make savings, obtain insurance and market their produce by opening an account and transact business on the mobile phone or bank	Small holder farmers	Input provision, Production, Storage and logistics, Transformation (Processing), Distribution and trade, Customer/consumption	Mobile interface	USSD Code *225# and SMS	Advanced deployment	Unknown	Interest from loans taken by farmers	Website: https://ke.kcbgroup.com/business/agri/mobigrow Daniel Huba daniel.huba@mastercard.com mobigrow@kcb.co.ke kcbmobi@kcbgroup.com

M-Shamba	M-Shamba Ltd	2012	It is an interactive platform providing current information to farmers on the agricultural activities they undertake or wish to start and connects farmers and traders to potential markets using a mobile phone	Agricultural research institutions and smallholder farmers	Input provision, Production, Distribution and trade	Mobile interface, Laptop/Desktop screen	Web based and SMS	Advanced deployment	Unknown	Unknown	Website: http://www.mshamba.net/
MTela	Inventia Agrarica Africa	Unknown	Addresses knowledge and distribution gaps in the agro-dealer distribution, by creating Automatic management of sales and inventory, Generation of customized sales report, Advice on the best product to use that is available on stock, Advisory services on crop/animal management, among others	Unknown	Input provision, Production, Distribution and trade	Mobile interface	Mobile-based POS	Development	Unknown	Unknown	Reinder van der Meer Email: vandermeerreinder@gmail.com Peter Njoroge
NAFIS	National Farmers Information Service	2011	Farmers get critical extension information by either browsing the internet or calling NAFIS numbers as information is updated by extension officers, and a voice-based service that contains summarized information that farmers access using mobile phones	All farmers and extension officers	Production	Voice, Mobile interface, Laptop/Desktop screen	Website, Mobile App and Mobile phone Voice call number 020-5100102	Advanced deployment	Unknown	Call charges	Website: http://www.nafis.go.ke Aggrey Adul Ochieng Adul.ochieng@nafis.go.ke
PlantWise	CABI	2011	Helps improve food security and the lives of the rural poor by reducing crop losses	All farmers	Input provision, Production	Mobile interface	SMS	Advanced deployment	Unknown	Donor funded part of the CGIAR	Website: www.plantwise.org Henry Mibei Email: H.Mibei@cabi.org plantwise@cabi.org Bruce Scott

SOKO+	Sokopepe Limited	Unknown	Links potato, banana and maize farmers to bulk buyers to help them earn more income and improve their livelihoods	Farmers and Buyers	Input provision, Production, and Distribution and trade	Mobile interface, Laptop/Desktop screen	SMS 20225 and Website	Advanced deployment	SMS Charges	Cash earned from SMS Charges	Website: http://sokoplus.sokopepe.co.ke/ Tel: +254 20 2427693
Umati Capital	Unknown	Jul-13	Offers credit and related payment platforms for agribusiness supply chains, retailer value chains and manufacturers of fast-moving consumer goods	Small and medium-sized online sellers	Input provision, Production, Storage and logistics, Transformation (Processing), Distribution and trade, Customer/consumption	Mobile interface, Laptop/Desktop screen	Web based	Advanced deployment	Fee charged when getting a loan (6% of amount borrowed)	Interest on loans	Website: https://umaticapital.com/
Vaell Leasing: The Tinga Product	Vael Leasing company	Unknown	It is designed to provide small-scale farmers with access to tractor services.	Farmers	Production	Mobile interface, Laptop/Desktop screen	Web based	Deployment	Unknown	Unknown	Website: http://www.vaell.com Email: ilease@vaell.com Tel: +254 731 440 832
WeFarm	Unknown	26th July 2017	It is a peer-to-peer knowledge-sharing platform for smallholder farmers where users ask and answer farming questions and share farming tips either via SMS or online.	Low income farmers below 1$ a day	Input provision/research, Production	Mobile interface, Laptop/Desktop screen	SMS to 22301 and Web based	Advanced deployment	Unknown	Unknown	Website: https://wefarm.org/ Dorothea Pease dorothea@wefarm.org Pauline Muchunu
KACE (Kenya Agricultural Commodity Exchange (KACE)	KACE (Kenya Agricultural Commodity Exchange (KACE)	1997	Provided daily market information on commodity prices, and facilitated links between farmers and buyers	Farmers and traders	Production and markets	Voice, Mobile interface, Laptop/Desktop screen	SMS, Email, Radio bulletins and Interactive Voice Response	Unknown	Unknown	Money received from Messaging system	Website www.kace.co.ke
uLima	Imperial Logistics company Resolve	2018	Provides farmers with access to information on crops, seeds, soil, livestock, agri-chemicals, weather updates and market prices.	Farmers	Input provision and production	Mobile interface, Laptop/Desktop screen	Website, Mobile app and USSD *693#	Early deployment	Unknown	Unknown	Website: www.ulima.co

Name	Founders	Year	Description	Target users	Area	Interface	Platform	Deployment		Pricing	Contact
Annona	Founded by Ashley King-Bischof and Zéluis Teixeira	2015	Create a global traceable food ecosystem and thus focuses most of its operations and functionality to traceability of farm produce	Farmers, Exporters and Importers	Production and trade/marketing	Mobile interface, Laptop/Desktop screen	Mobile app and Website	Advanced deployment	Unknown	Exporters pay either $84 or $199 per month and Importers pay $299 or $647 per month depending on premiums	Website: https://annona.co/ Tel: +254 799 717 047 Email: info@annona.com
Twiga Foods	Blue Haven Initiative, AHL Venture Partners, 1776	2013	Helps retail outlets get access to fresh farm produces. The application provides a platform for cashless business-to-business supply	Farmers and Vendors	Marketing	Mobile interface, Laptop/Desktop screen	Mobile app and Website	Advanced deployment	Unknown	Unknown	Website: https://twiga.ke/ Mailu Mwau info@twiga.ke Tel: +254 709 258000
Fresh n Easy	Mara Farming group of companies	2013	Focuses on need to produce, package and make available fresh array of vegetables and fruits tailored to suit individual client preference	Clients ordering fruits and vegetables online	Marketing	Mobile interface, Laptop/Desktop screen	Website	Deployment	Unknown	Unknown	Website: www.freshneasy.co.ke Tel: +254 707 110123
Mkulima young	ACLEOPS	2013	Aimed at encouraging young people to engage in agriculture and reduce reliance on middle-men	Linking farmers and buyers	Production and marketing	Mobile interface, Laptop/Desktop screen	Mobile app and Website	Advanced deployment	Unknown	Unknown	Website: https://www.mkulimayoung.com/ Email: info@mkulimayoung.com Tel: +(254) 710 848 002
FreshPro	Fresh Pro Farms Ltd	Unknown	Markets traceable horticulture produce using assigned codes that can be tracked back to the point of production	Clients ordering fruits and vegetables online	Marketing	Mobile interface, Laptop/Desktop screen	Mobile app and Website	Development	Unknown	Unknown	Website: www.freshpro.co.ke Email: fresh@freshprofarms.com Tel: +254 791 010500

Bonded Groceries	Bonded Groceries Ltd	Unknown	Offers an interface for interaction with consumers and assign traceability codes to products sold in the local and international markets	Clients ordering fruits and vegetables online	Production and marketing	Laptop/Desktop screens	Website	Development	Unknown	Unknown	Website: https://www.bondedgroceries.co.ke/E mail: sales@bondedgroceries.co.ke info@bondedgroceries.co.ke Tel: +254 711 843 321,+254 780 042 222
Geo Data for Agriculture and Water (G4AW)	Netherlands Ministry of Foreign Affairs	Unknown	Uses satellite data to provide advice to farmers in Kenya through two main projects; CROPMON and Geodatics	Farmers	Input provision, production and post-harvest handling	Mobile interface, Laptop/Desktop screen	Website portal and mobile application	Deployment	Unknown	Unknown	Website: https://g4aw.spaceoffice.nl/en/
Smart Cow	Intersoft Eagles Limited	2017	Help dairy farmers track records and see venture is making profits or losses.	Dairy Farmers	Production	Mobile interface	Mobile app	Development	Unknown	Farmers/Users Pay a subscription fee for the app	Tel: +254 710 610 618
Agronomic advisories	Pawa-Farm	2016	A platform that provides agronomic advisories to farmers on integrated weather and good agricultural practices based on weather forecasts and agronomic requirements	Farmers and traders	Input provision, production and marketing	Mobile interface, Laptop/Desktop screen	Web portal and sms	Early deployment	Cost of sending SMS	Social enterprise using revenue sharing and hybrid premium cost strategy	Website www.pawa-farm.com

AgriWallet	Dodore Kenya Ltd	Unknown	Agri-wallet is an innovative mobile business account to save, borrow and pay for income generating activities to increase food security and fight poverty.	Small scale farmers, buyers	Unknown	Mobile interface	Mobile phones	Unknown	Loans	Interest on loans	Website: https://agri-wallet.com/ Sijmen de Hoogh sdehoogh@dodore.org Gidraf Wachira
Apollo Africa	Apollo Africa	Unknown	Apollo helps farmers in emerging markets maximize their profits using agronomic machine learning, remote sensing, and mobile phones to deliver financing, farm products, and customized advice to smallholder farmers with radical efficiency and scalability. Also assesses farmer credit risk and customizes each product to a farmer's specific location using satellite data, soil data, farmer behavior data and crop yield models.	Farmers in emerging markets	All stages of value chain	Mobile interface	Mobile phones	Unknown	Unknown	Unknown	Website: https://apolloagriculture.com Eli Pollak eli@apolloagriculture.com
Agri-getter.com	Agri-getter Ltd	Unknown	It is a data and technology-based agriculture solutions provider. Through data and technology systems we de-risks agricultural challenges due to climate change offering tailored solutions based on remote and field accessed data.	Agricultural stakeholders	Unknown	Mobile interface, Laptop/Desktop screen	Desktop, Tablet, and mobile based using USSD and Mobile apps	Unknown	Unknown	Unknown	Website: https://www.agri-getter.com/ Amos Tabalia ntabalia@agri-getter.com
DrumNet Kenya	Pride Africa	2002	Offers support services to smallholder farmers in Kenya by providing access to information, financial services, and markets	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Vince Groh

FinancialXS	Financial Access Ltd	Unknown	Design and deliver solutions to accelerate financial inclusion for smallholder farmers across landscapes and agricultural supply chains at scale. We use our data-driven analytics, agri sector knowledge and operational banking experience to develop less risky, scalable and sustainable farmer financing models and investment opportunities for banks, microfinance institutions and (impact) investors, at lower cost	Small holder farmers	All value chain stages	Unknown	Unknown	Unknown	Unknown	Unknown	Website: http://www.financialxs.com/ Veerle Haagh veerle.haagh@financialxs.com
Twiga	Future Water	2018	Aims to provide actionable geo-information on weather, water, and climate in Africa through innovative combinations of new in situ sensors and satellite-based geo-data.	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Website: https://www.futurewater.eu/ Martijn de Klerk m.deklerk@futurewater.nl
G-Soko	Eastern Africa Grain Council (EAGC)	2016	is an online trading platform that links smallholder farmers to grain buyers through a networked and structured market mechanism	Small holder grain farmers, warehousing, banks, and grain warehouses owners	Unknown	Laptop/Desktop screens	Web based	Unknown	Paying to acquire certificates for warehouses and % fee incurred for the transaction and deduction of any charges incurred at the warehouse	Amount incurred in getting warehousing certificate and % fee for the transaction and deduction of any charges incurred at the warehouse	Website: http://g-soko.com/ Tel: +254 710 607 313

53

Kilimo Booster Agricultural Loans	Musoni Microfinance	2016	Financing smallholder farmers to improve their farms and earn a higher income	Small holder farmers	All value chain stages	Unknown	Unknown	Advanced deployment	Farmers and groups pay interest on loans and upfront fees	Interest got from loans	Juliet Ongwae julietongwae@musoni.co.ke
Shamba Digital	Empire digital ventures limited (EDVL)	Unknown	Enhance the performance of the agricultural industry with the main aim of transforming subsistence farmers into Agripreneurs providing a friendly and easy to use platform that helps farmers manage their farm-like businesses.	Agripreneurs	Unknown	Mobile interface, Laptop/Desktop screen	Web based and Mobile application	Unknown	Unknown	Unknown	Website: http://www.shambadigital.com/ Jamal Mohamed Jmohamed@shambaintel.com Elisha Bwatuti
SoilCares	AgroCares	Unknown	Combine smart applications with the nutrient Scanner and get on-the-spot insight into soil fertility. Devices and applications are easy-to-use on your smartphone and based on a cutting edge big data solution for fast soil analysis.	Unknown	Unknown	Mobile interface, Laptop/Desktop screen	Web based and Mobile application	Unknown	Unknown	Unknown	Website: https://www.agrocares.com/en/services/soilcares/ David Marcelis David.Marcelis@soilcaresresearch.com
Ujuzi Kilimo	Ujuzi Kilimo	Unknown	Use sensors to precisely capture soil and farm data from which farmers get real-time actionable and easy to understand advice on fertilizers, seeds, weather and best practices to ensure they practice productive and sustainable agriculture.	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	http://ujuzikilimo.com/ Brian brian@ujuzikilimo.com
Vipimo	Upande Limited	Unknown	Vipimo is an Internet of Things (IoT) solution which enables our customers to get remote readings of various sensors straight from the field to the comfort of their phone or computer.	Domestic users, agricultural sector, utility companies	Unknown	Mobile interface, Laptop/Desktop screen	Web based and Mobile apps	Unknown	Unknown	Unknown	Website: https://upande.com/ Mark de Blois mark@upande.com

Agrikore	Cellulant	Unknown	Agrikore is a blockchain based smart-contracting, payments and marketpace system that ensures 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.	Farmers, FMCGs, Agriculture inputs providers, produce aggregators, insurance companies, financial institutions, governments	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Website: https://www.cellulant.com/ David Waithaka david.waithaka@cellulant.com
Tulaa	Tulaa Ltd	2017	Provides smallholder farmers with quality agricultural inputs on credit and brokers the sale of their crop at harvest time.	Small holder farmers, Suppliers and buyers	Unknown	Mobile interface	Mobile app	Unknown	Loans	Interest from loans	Website: https://www.tulaa.io/ Vishal Ajmera info@tulaa.io Tel: +254 743 710 252
Climark Project (Mobile for Livestock)	Amfratech Ltd	Unknown	This will enable the local community be aware of the weather patterns in the short term and long term for pro-active actionable recommendations in order to safeguard their livelihoods	Pastoralist farmers	Unknown	Mobile interface, Laptop/Desktop screen	Mobile app and Web based	Unknown	Unknown	Unknown	Website: http://amfratech.com/ Jeremiah Mutungi Jeremiah.mutungi @amfratech.com Racho Godana Frankline Agolla
2SCALE	BoP Innovation Center	Unknown	2SCALE offers a range of support services to private partners – companies and farmer groups – enabling them to produce, transform and supply quality food products to local, national and regional end-user markets, including Base of the Pyramid consumers.	Private partners – companies and farmer groups	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Website: http://www.bopinc.org Niek van Dijk vandijk@bopinc.org Beryl Oyier Email: info@bopinc.org

Viazi Soko Platform	National Potato Council of Kenya (NPCK)	Unknown	Is an online and SMS based platform that allows potato farmers to get information on certified seed and market ware potatoes. NPCK and partners also use the platform to send advisory messages to the farmers. The messages sent to farmers can be in form of an advertisement, announcement, or advisory but must be factual and should not exceed 160 characters.	Potato farmers, NPCK and partner companies	Unknown	Mobile interface	SMS based by sending an SMS to 22384 and Web Portal	Unknown	Bulk SMS charges including a flat rate of KSh. 20000 for 1-12500 subscribers and rates charged for 12500 subscribers	Bulk SMS charges	Website: https://www.npckviazisoko.com/ Obed Kipyego
Herd Management software	PerfometeR	Unknown	A herd management software focusing on middle-level and large scale dairy farmers in Kenya and East Africa. The system requires a PC for installation of the software (mainly to be on the farm for entry or records) and is also linked to mobile devices for data entry reviews and report.	Middle-level and large scale dairy farmers	Unknown	Laptop/Desktop screens	Desktop or Laptop	Unknown	Unknown	Unknown	Website: https://perfometer.org/dairy-advisory/ Email: info@perfometer.org James Ngatia
Connected Farmer Alliance	TechnoServe	2012	CFA works with farming communities and agribusiness partners across the three countries to develop and scale mobile applications that enable rural households to make and receive payments securely, access other financial services such as micro-insurance, and connect to local and multinational agribusinesses.	Farming communities and agribusiness partners	Unknown	Mobile interface	Mobile apps	Unknown	Unknown	Unknown	Website: http://www.technoserve.org/our-work/projects/connected-farmer-alliance John Logan

TruTrade	TruTrade	Unknown	an online and mobile enabled trading and payment platform for collaborative supply chain management. This allows for the capture of all costs, analysis of transaction viability and price setting; registration of farmers and triggering payments; and tracking of produce from collection to delivery.	Unknown	Unknown	Mobile interface, Laptop/Desktop screen	Mobile app and Web based	Unknown	Unknown	Unknown	Website: http://www.trutradeafrica.net/ Email: info@trutradeafrica.net Tel: +254 (0)725 850 906 Cheryl Chelule Joseph Mulindi
Kenya Market Trust Website	Kenya Market Trust	Unknown	It is a Kenyan organization that works in partnership with the private sector; county & national governments; Associations; Local and Internationals Partners to unleash large scale, sustainable market growth by changing the underlying incentives, capacities and rules that shape how market systems work.	All agricultural value chain actors	Unknown	Laptop/Desktop screens	Web based	Unknown	Unknown	Donor funded	Website: http://www.kenyamarkets.org Email: info@kenyamarkets.org Tel: +254 722 201 233 Charles Warria Elvis Karanja
ILRI Website	International Livestock Research Institute	Unknown	Improving better living through livestock	All agricultural value chain actors	Unknown	Laptop/Desktop screens	Website	Unknown	Unknown	Unknown	Website: https://www.ilri.org/kenya Email: ILRI-Kenya@cgiar.org Phone: +254-20 422 3000 Andrew Mude
CGIAR Platform for Big Data in Agriculture	CGIAR	Unknown	It is a platform where information becomes power: power to predict, prescribe, and produce more food, more sustainably.	Unknown	Unknown	Laptop/Desktop screens	Website	Unknown	Unknown	Unknown	Website: https://www.cgiar.org

Name	Organization		Description	Target users	Value chain	Device	Type	Deployment		Function	Contact
Kenya Tea Development Authority Website	Kenya Tea Development Authority (KTDA)	Unknown	Is a provider of comprehensive services to more than 565,000 small tea farmers such as agri-extension, transportation, Transformation (Processing), and marketing	Tea farmers and all tea stakeholders	All value chain stages	Laptop/Desktop screens	Website	Advanced deployment	Unknown	Sale of tea products	Website: https://www.ktdateas.com Email: info@ktdateas.com Tel: 254 - 020 3227000
World Food Program Website	United Nations	Unknown	Pushes for inclusion of food and nutrition security in the government's 'big four' priorities, constitutional changes that devolve administrative responsibilities to county governments, and the country's openness to innovation offer opportunities for the achievement of Sustainable Development Goal 2 on Zero Hunger and improved nutrition.	Farmers and stakeholders organizations	All value chain stages	Laptop/Desktop screens	Website	Advanced deployment	Unknown	Unknown	Website: http://www1.wfp.org/countries/kenya Tel: +254 20 7621234
Kuza Hub	Kuza	Unknown	Kuza helps new farmers access knowledge, skills and on-farm support from experienced farmers and experts	Unknown	Unknown	Mobile interface, Laptop/Desktop screen	Online blog	Unknown	Unknown	Unknown	Website: https://blog.kuza.io
Farmers Pride Website	Farmers Pride Africa	Unknown	is a Last mile distribution of life changing agriculture solutions enterprise through agro dealer franchise model, village youth agents and mobile technology	Unknown	Unknown	Mobile interface, Laptop/Desktop screen	Website	Unknown	Unknown	Unknown	Website: http://farmersprideafrica.com Tel: +254 725 718069 Email: info@farmersprideafrica.com

Crop Mapping Mobile Tech	FarmIT	Unknown	Provides timely and reliable agronomic information to small scale horticultural farmers via use of SMS. During registration through a series of SMS prompts, the farmer will indicate the planting date which triggers other reliable agronomic information mapped depending on the crop life stages.	small scale horticultural farmers	Unknown	Mobile interface	SMS	Unknown	Unknown	Unknown	Website: https://farmit.co.ke / Email: info@farmit.co.ke Tel: +254 713 124 737
Mkulima E-plus	FarmIT	Unknown	Online Agro-vet offering agricultural inputs from seeds, to crop protection and enhancement inputs such as fertilizers, pesticides, foliars, fungicides, to tools such as Knap-sacks, shade nets, drip lines, trays, soil media from different companies enabling farmers to compare and make an order which is delivered within two hours	Farmers seeking agro-vet services	Unknown	Mobile interface, Laptop/ Desktop screens	Website	Unknown	Unknown	Unknown	Website: https://farmit.co.ke / Email: info@farmit.co.ke Tel: +254 713 124 737
Kikapu Gardens	Farm IT	Unknown	Delivery of Fresh, affordable and reliable agricultural groceries around Nairobi area. Kikapu garden deals with delivery of fresh agricultural goods which are ordered on our Mkulima e-plus platform to enable consumers living in Nairobi city to access fresh and affordable quality agricultural produce that are being sought directly from farmers	Users seeking grocery services	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Website: https://farmit.co.ke / Email: info@farmit.co.ke Tel: +254 722 718 145

ANNEX 2: The Six Service Provider Clusters

Crop and Livestock management information	Marketing information	Farm/Field data Capture	Traceability & Customization	Financial Services	Others (Insurance/Tractor Services)
1. Kenya Agricultural and Livestock Research organization	Sokopepe Limited	Octagon Data Systems Limited	Mara Farming group of companies	Dodore Kenya Ltd	Acre Africa Platforms / Syngenta Foundation for Sustainable Agriculture
2. aWhere company	Acumen Fund, Soros Economic Development Fund and the Grameen Foundation (USA)	African Technology Policy Studies Network (ATPS)	Apollo Africa	Unknown	Kenya Commercial Bank (KCB) and MasterCard Foundation
3. Farm Radio International	M-Shamba Ltd	Regional Centre for Mapping of Resources for Development's (RCMRD)	BoP Innovation Center	Musoni Microfinance	Vael Leasing company
4. Ycenter Inc. of Philadelphia, USA, together with P4ACAD	Inventia Agrarica Africa	Agri-getter Ltd	Kenya Tea Development Authority (KTDA)	TechnoServe	
5. HIVOS, Programme for Agricultural Capacity Development in Africa supported by	Sokopepe Limited	Future Water	Founded by Ashley King-Bischof and Zéluis Teixeira	Mercy Corps, MasterCard Foundation and Safaricom	

	CTA and GODAN				
6.	Green Dreams Tech Ltd	KACE (Kenya Agricultural Commodity Exchange (KACE)	AgroCares	Bonded Groceries Ltd		
7.	Biovision Africa Trust (BvAT)	Blue Haven Initiative, AHL Venture Partners, 1776	Ujuzi Kilimo			
8.	The Mediae Company	Fresh Pro Farms Ltd	Upande Limited			
9.	National Farmers Information Service		Amfratech Ltd			
10.	CABI	Equator Chillies	United Nations			
11.	Unknown	Pride Africa				
12.	Media HQ, SNV, Incentro, Dalberg Research and Rabobank Foundation	Financial Access Ltd				
13.	Imperial Logistics company Resolve	Eastern Africa Grain Council (EAGC)				
14.	Netherlands Ministry of Foreign Affairs	Cellulant				

15. Intersoft Eagles Limited	Tulaa Ltd				
16. Pawa-Farm	TruTrade				
17. Empire digital ventures limited (EDVL)	Kenya Market Trust				
18. PerfometeR	Farm IT				
19. International Livestock Research Institute	Eastern Africa Farmers Federation (EAFF) and Mobile Decisioning Africa Limited (MO-DE)				
20. CGIAR					
21. Kuza					
22. Farmers Pride Africa					
23. National Potato Council of Kenya (NPCK)					
24. FarmIT					
25. FarmIT					

ANNEX 3: Level of Usage of Digital Services and Digital Appliances in the last 3 Months from any Location

Main employer for main job / business	Number (%) subscribed to:		Number (%) that used a Digital Appliance				
	Money Transfer platform	Mobile banking platform	Television	Radio in	Mobile	Computer (Desktop)	Internet
National Government							
Civil Service Ministries	97.61	52.87	80.43	90.45	98.81	43.44	69.45
Judiciary	100	50	100	100	100	100	100
Parliament	100	100	100	100	100	100	100
Commissions	96.97	24.24	78.79	84.85	96.97	12.12	84.85
State Owned Enterprise/Institution	97.36	43.56	78.57	87.97	99.25	43.98	62.41
Teachers Service Commission (TSC)	99.06	51.96	83.31	92.51	99.84	43.21	68.17
County Government	91.47	27.54	61.23	82.87	95.72	18.26	34.53
Private Sector Enterprise	77.02	15.36	46.81	83.89	82.83	11.52	22.54
International Organizations/Ngo	96.47	51.76	74.12	83.53	97.65	50.59	61.18
Local Ngo/CBO	82.95	40.91	58.43	75.28	89.89	28.09	49.44
Faith Based Organization	97.3	37.84	74.59	84.32	99.46	41.08	53.51
Self Employed-Modern	93.71	31.63	70.13	85.09	97.08	24.42	41.67
Informal Sector 'Jua Kali' (Employed)	84.17	14.43	59.38	83.76	92.1	7.05	23.71
Self Employed – Informal	88.11	17.66	57.34	83.22	94.39	7.41	22.14

Small Scale Agriculture (Employed)	100	0	100	0	100	100	100
Self-Small Scale Agriculture	70.29	7.71	32.16	78.69	84.07	1.52	5.49
Pastoralist Activities (Employed)	40.3	3.54	11.74	42.33	41.83	1.14	2.84
Self-Pastoralist Activities	50.71	6.09	7.47	37.64	65.99	0.15	0.94
Individual/Private Household	68.34	5.59	42.73	80.22	77.5	3.01	9.75
School Boards (BoM) Employees	94.89	22.68	58.79	83.76	96.18	27.71	45.54
Other (Specify)	65.54	7.08	35.47	77.99	83.57	3.62	18.11
Total	76.84	14.39	44.45	78.88	84.02	8.2100	18.0100
Statistical Test							
Pearson chi2(22)	2500	2800	3900	3100	3700	4500	5400
Pr	0.000	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
gamma	0.2908	0.3782	0.2711	0.23	0.2744	0.528	0.4456
ASE	0.008	0.009	0.007	0.008	0.009	0.011	0.008

ANNEX 4: The Number of active SIM lines Owned

Main employer for main job / business	Active SIM lines										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**8**	**9**	**11**	**Total**
National Government											
Civil Service Ministries	0.48	47.02	43.44	7.88	1.19	0	0	0	0	0	100
Judiciary	0	66.67	33.33	0	0	0	0	0	0	0	100
Parliament	0	0	100	0	0	0	0	0	0	0	100
Commissions	3.03	45.45	45.45	6.06	0	0	0	0	0	0	100

State Owned Enterprise/Institution	1.13	52.26	39.47	6.39	0.75	0	0	0	0	0	100
Teachers Service Commission (TSC)	0.16	49.22	44.2	5.02	1.41	0	0	0	0	0	100
County Government	6.85	60.5	29.27	2.86	0.3	0.23	0	0	0	0	100
Private Sector Enterprise	34.97	44.35	18.94	1.4	0.21	0.08	0.02	0.01	0	0.02	100
International Organizations/Ngo	3.53	50.59	42.35	3.53	0	0	0	0	0	0	100
Local Ngo/CBO	15.73	52.81	23.6	7.87	0	0	0	0	0	0	100
Faith Based Organization	2.16	51.35	36.22	8.11	2.16	0	0	0	0	0	100
Self Employed- Modern	3.52	55.95	35.83	3.82	0.73	0	0	0	0.15	0	100
Informal Sector 'Jua Kali' (Employed)	14.36	56.77	27.07	1.56	0.2	0.04	0	0	0	0	100
Self Employed – Informal	8.91	60.97	28.09	1.77	0.2	0.06	0	0	0	0	100
Small Scale Agriculture (Employed)	0	100	0	0	0	0	0	0	0	0	100
Self-Small Scale Agriculture	26.49	58.9	13.98	0.55	0.07	0	0	0	0	0	100
Pastoralist Activities (Employed)	80.15	17.56	2.23	0.06	0	0	0	0	0	0	100
Self-Pastoralist Activities	44.48	50.65	4.72	0.07	0.07	0	0	0	0	0	100
Individual/Private Household	37.41	48.79	13.15	0.6	0.05	0	0	0	0	0	100
School Boards (BoM) Employees	4.15	59.42	34.19	1.92	0.32	0	0	0	0	0	100
Other (Specify)	26.4	55.06	17.7	0.56	0.28	0	0	0	0	0	100
Total	26.92	52.04	19.43	1.36	0.2	0.04	0.01	0	0	0.01	100
Statistical Test											
Pearson chi2(198)	6.80E+03	Pr	0.000								
gamma	-0.216	ASE	0.006								

ANNEX 5: The Mean Weekly Airtime (Ksh) Spent on Talk time, Internet and Movies & Music

Main employer for main job / business?	Talk time		Internet		Movies and Music	
	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean
National Government						
Civil Service Ministries	510	41	130	26	7	3
Judiciary	362	143	62	29	0	0
Parliament	500	0	250	250	0	0
Commissions	432	35	72	9	3	3
State Owned Enterprise/Institution	372	22	84	9	7	3
Teachers Service Commission (TSC)	320	11	78	5	4	1
County Government	252	11	44	4	3	1
Private Sector Enterprise	128	3	21	1	3	
International Organizations/Ngo	423	50	110	19	16	8
Local Ngo/CBO	313	44	70	14	16	10
Faith Based Organization	291	24	78	17	10	8
Self Employed- Modern	397	22	60	6	5	1
Informal Sector 'Jua Kali' (Employed)	169	4	15	1	4	
Self Employed – Informal	212	4	21	2	4	
Small Scale Agriculture (Employed)	100		200		0	
Self-Small Scale Agriculture	88	1	3		1	
Pastoralist Activities (Employed)	23	2	1			
Self-Pastoralist Activities	82	3				

Individual/Private Household	67	2	5		1	
School Boards (BoM) Employees	160	8	35	4	3	1
Other (Specify)	70	5	8	2	3	2

ANNEX 6: Activities for which Internet was used for Private Purpose in the last 3 Months

Main employer for main job / business?	Activity (%)								
	A	B	C	D	E	F	G	X	Total
National Government									
Civil Service Ministries	74.04	17.89	3.16	0.35	0	0	4.56	0	100
Judiciary	66.67	16.67	16.67	0	0	0	0	0	100
Parliament	100	0	0	0	0	0	0	0	100
Commissions	92.86	3.57	3.57	0	0	0	0	0	100
State Owned Enterprise/Institution	66.27	18.07	1.81	1.2	0	0	12.65	0	100
Teachers Service Commission (TSC)	78.52	6	7.16	0.69	0.23	0	7.39	0	100
County Government	73.88	9.6	4.69	1.12	0	0	10.49	0.22	100
Private Sector Enterprise	76.59	8.51	2.31	1.39	0.05	0.96	10.05	0.14	100
International Organizations/Ngo	73.08	21.15	1.92	0	0	0	3.85	0	100
Local Ngo/CBO	59.09	20.45	6.82	2.27	0	0	9.09	2.27	100
Faith Based Organization	76.77	8.08	5.05	0	1.01	0	9.09	0	100
Self Employed- Modern	77.11	10.56	4.23	0.35	0	0	7.75	0	100
Informal Sector 'Jua Kali' (Employed)	79.93	1.99	4.15	0.5	0.33	0.5	12.6	0	100

Self Employed – Informal	83.59	2.86	2.78	0.17	0.08	0.51	9.93	0.08	100
Small Scale Agriculture (Employed)	100	0	0	0	0	0	0	0	100
Self-Small Scale Agriculture	85.45	0.75	3.17	0	0.56	0.19	9.7	0.19	100
Pastoralist Activities (Employed)	64.44	0	4.44	6.67	0	4.44	17.78	2.22	100
Self-Pastoralist Activities	84.62	0	0	0	0	7.69	7.69	0	100
Individual/Private Household	76.13	1.19	2.39	0.95	0.24	1.67	17.42	0	100
School Boards (BoM) Employees	71.74	10.14	2.17	3.62	0	0	12.32	0	100
Other (Specify)	76.92	1.54	1.54	6.15	0	0	13.85	0	100
Total	78.13	6.59	3.26	0.91	0.14	0.58	10.28	0.12	100
Pearson chi2(140)	533.3981	Pr	0.000						
gamma	-0.0532	ASE	0.018						

Activity Key

Seeking health information	A
Making an appointment with a health practitioner via a website/ email	B
Getting information from any government website	C.

Reading newspaper online	D
Internet banking	E
Telephoning over the internet/ voip	F
Selling goods or services	G
Other (specify)	X