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Status and Readiness for ICTs in Ghana's Agriculture

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Abstract

The rapid spread of mobile phones and networks in rural Africa has stimulated the development of Information and Communications Technology (ICT)-based initiatives in the agriculture sector in most African countries. Much of the focus to date has been on offering services, such as information, marketing and financial transactions, to farmers via their mobile phone. Other promising applications of ICTs, such as big data gathering and analytics, social networks, robotics, the internet of things or remote sensing, are increasingly attracting attention, but have not yet been widely applied. The Objectives of this study was to identify opportunities for better integrating existing initiatives, with a focus on using ICTs to build the technical and commercial capacities of producer organisations to serve as competent intermediaries between the millions of dispersed smallholders and other value chain actors. The study also examined options for strengthening the enabling environment for providers of agricultural ICT solutions to develop and commercialise their applications, in particular those that leverage more advanced ICTs to transform the agriculture sectors in Africa. The study was in two parts (1) stocktaking study which focused on state of the infrastructure/ hardware, ICT innovation environment and status of ICT4Ag services, (2) Case study to provide detailed analysis of selected ICT4Ag services. A combination of approaches including desk research, analysis of secondary data (e.g. from statistics offices, internet, companies) and users' survey were used to gather data. Key factors leading to improvements in ICT Infrastructure were (1) conducive policy and regulatory environment, (2) emergence of innovation spaces e.g. Ghana Multimedia Incubator Centre, (3) investments by both private and public sector e.g. national fibre network and (4) financial incentives and support systems e.g. corporate tax incentives. Several actors including government, private sector, international regulatory institutions, international development institutions, NGOs and donor agencies have played different roles that have contributed to the growth of the sector. There are however gaps such as inadequate implementation of policies and enforcement of regulations, limited digital skills reduces ICT use, relatively high cost of internet data especially to the vulnerable in rural areas and no uniformity in quality of service- poor in some areas. In terms of users' access factors that have brought improvement were (1) establishment of Ghana Investment Fund for Electronic Communications (GIFEC) to bridge the digital divide between the urban and rural areas, (2) innovative pricing e.g. bundling for data and MTN zone for calls, (3) consumer protection from all forms of abuse, for instance, with the passage of Data Protection Act, 2012 Act 843, (4) E-skills Development e.g. integration of ICT in education policy and introduction of ICT into the curriculum of both basic and second cycle schools, and (5) various programmes supported by development partners. In terms of ITC service provision in agriculture, Status of digitalization in agriculture, it was found that most services established between 2000 and 2017 targeting farmers and other value chain actors. Digital services offered include extension and market Information, data capture, market linkage, financial services and traceability. Key factors leading to development of the services were collaboration with public and private sectors, and development partners and NGOs, wide availability of mobile phones and other devices, and funding support for development and deployment. The impacts of services include good database on farmers, increased access by farmers to information and increased market access. In conclusion, there is a need to improve policy implementation and law enforcement, introduce policies to support deployment, uptake of ICTs and scaling up, increase investment in advanced and emerging ICTs e.g. sensors (drones), robotics, increase funding support for start-ups and promote informal ICT education for actors in the agricultural sector

Introduction

ICT-enabled services are contributing to the evolution of the various sectors of the global economy, including agricultural sector. The rapid spread of mobile phones and networks in rural Africa has stimulated the development of information and communication technology (ICT)-based initiatives in the agricultural sector in most developing countries. For example, farmers in Bangladesh have been using ICT-enabled services based on mobile telephones to monitor market prices of rice, vegetables and other farm produce (Dholakia and Kshetri, 2002). Dholakia and Kshetri further report that farmers in remote areas of Cote d'Ivoire use mobile telephones to track the hourly fluctuations in cocoa and coffee prices.

Much of the focus to date has been on offering services, such as information, marketing and financial transactions to farmers via their mobile phones. Most of these initiatives still depend on external financial support, remain small, often duplicated and have limited impact. Other promising applications of ICTs, such as large-scale data gathering and analytics, social networks, robotics, the Internet and remote sensing are increasingly attracting attention, but have not yet been widely applied. Thus, the significant potential of ICTs to improving productivity and market integration in Africa has not yet been fully realized.

In Ghana, there is a gradual integration of ICT-enabled services in the agricultural sector, and this is transforming interactions and networking among the actors of the entire agricultural value chain (GSMA, 2018). ICT-enabled services in the agricultural sector have a wide array of features and functions, including those for delivering extension services, market prices survey, and weather forecast services (GSMA, 2017). Though the ICT-enabled services in the agricultural sector of Ghana are not in their advanced stage, there is relative growth and contributions towards the improvement of the sector. GSMA (2017) cites some ICT-enabled services in Ghana's agricultural sector to include Vodafone Farmers' Club, MTN's mAgric and Farmerline. As will be shown later in this report, there are a number of such organisations providing critical support to agricultural development in the country. What is required is the support to cradle the development of these organisations to support agricultural development in the country.

Socioeconomic indicators of Ghana

Ghana has a land size of 238.5 kilometres and an estimated population of 28.83 million in 2017. The annual population growth rate is 2.2 and population density of 126.7 in 2017 an increase from the 64.3 of 1990. This gives an indication that Ghana has a fast-growing population. Life expectancy increased from 57 years in 1990 to 63 years in 2017 and there is improved quality of life.

Ghana falls within the lower bracket of middle-income economy, with a GDP growth rate of 8.1. In the recent past, agriculture was a key contributor to the country's gross domestic

product, but the services sector has overtaken agriculture, which contributed 20% to GDP in 2017. Table 1 provides information on some of the key economic indicators of the country.

Table 1: Socioeconomic Indicators

Indicator	Value
Surface area (sq. km) (thousands)	238.5
Population, total (millions)	28.83
Population growth rate (annual %)	2.2
Population density (people per sq. km of land area)	126.7
GDP growth (annual %)	8.1
GDP (current in billion US\$)	59
Life expectancy at birth, total (years)	63
Poverty headcount ratio at \$1.90 a day (2011 PPP) (% of population (2010))	12
GNI per capita, Atlas method (current US\$)	1880
GNI per capita, PPP (current international \$)	4280
Agriculture, forestry, and fishing, value added (% of GDP)	20
Primary completion rate, total (% of relevant age group)	95
School enrolment, secondary (% gross)	70
Electric power consumption (kWh per capita)	355

Source: World Bank (2017). Data retrieved on 27th January, 2019

Study Objective

This study sought to identify opportunities for better integrating existing ICT-based initiatives and thereby offering integrated solutions to farmers and other actors in the value chain. The research also assessed the utility of ICTs to build the technical and commercial capacities of producer organizations (POs) to serve as competent intermediaries between the millions of dispersed smallholders and other value chain actors. In addition, the study investigated options for strengthening the enabling environment for providers of agricultural ICT solutions

to develop and commercialize their applications, especially those that leverage on advanced ICTs to transform the agriculture sector in Ghana. The main objective of the research, therefore, was to take stock and assess the status of and readiness for ICTs in agriculture in Ghana.

The specific objectives were to:

- Assess the state of ICT infrastructure/hardware in Ghana
- Identify ICT-related policies, regulations and authorities; and
- Identify, catalogue, and analyse ICT-enabled services in the agriculture sector, with a focus on the entire value chain.

Methodology

Study Approach

The study was in three parts. The target populations were ICT service providers and mobile phone users. Part one focused on desk research or internet search, involving mobile network coverage, location of towers/masts, submarine and terrestrial fibre networks, etc. Secondary data was also collected from national ICT records and statistics from relevant documents of the National Communication Authority (NCA) and from identifiable ICT companies and service providers. There was also an assessment of the ICT innovation environment and status of ICT4Ag services in part one of the study. The second part was an end-user survey to assess the extent of ICT usage among selected segments of urban and rural populations. The third part of the study involved in-depth assessment of selected ICT4Ag services using case study approach.

Data Collection and Analysis

Both quantitative and qualitative approaches were employed to collect data. Quantitative data was accessed from relevant documents to assess the state of ICTs in Ghana. This included ICT infrastructure, coverage, subscribers, market share of service providers, types and use of phones, penetration rates and number of towers/masts, among others. Additional qualitative data was collected to assess the status and potential of ICTs in the agricultural, food and nutrition sector so as to identify opportunities for better integrating existing initiatives and offer solutions to farmers and other actors in the agricultural commodity value chains. Through internet search, ICT4Ag service providers were identified. After eliminating the service providers (SPs) with limited ICT usage in agriculture, twenty-four (24) ICT4Ag services were selected and contacted for information regarding: start date/end date, functions of the service, target users, value chain stage(s), types of ICT used for data gathering and analytics, ICTs used for dissemination; status of deployment, cost to users, funding/revenue generation model, contact point and the URL. The SPs were then clustered on the basis of their major

functions. Focus group discussions involving ICT services providers were also conducted to have a better understanding of their services and how the services are related.

For the end-user survey, a structured questionnaire was prepared and formatted on an Open Data Kit (ODK) platform to collect quantitative data. Data was collected in three towns that were purposively selected for the survey; one urban town (Dzorwulu), one peri-urban settlement (Dawhenya), and one rural community (Damfa- Otinibi) all in the Greater Accra Region of Ghana. A two-stage purposive sampling technique was used to select respondents for interview. The first end-user found on the street was purposively selected for the interview. Thereafter, every third end-user, aged 18 years and above was purposively interviewed irrespective of their socio-demographic characteristics. A total of 300 end-users were covered in the survey; that is, 100 respondents in each selected town. The questions asked included: type of phone, number of registered SIM, ability to send SMS messages, main use of phone, factors influencing choice of phone acquired, source of internet, cost of data, and types of ICT devices used and their costs.

From the 24 ICT4Ag services, three (3) were selected for detailed analysis. These three services were selected because they provided diverse services along the value chain and were also willing and ready to provide relevant information about their services. The case studies employed in-depth interview, which was recorded and later transcribed. A report for each case study was prepared detailing the profile/background, target clients, source of funds and collaborators, achievement/successes and lessons learnt.

Organization of the Report

The report is presented in two sections. Section one comprises five chapters: Chapter 1 presents the introduction and methodology. The status of ICT market is discussed in Chapter 2. Status of ICT infrastructure and innovation environment is presented in Chapter 3. While Chapters 4 and 5 deal with status of ICT4Ag services and conclusions, respectively. Section two presents the case study reports of three ICT4Ag services in Ghana.

State of the ICT Market

The Ghana ICT market is characterized by vibrant competition, until recently, among six international mobile network companies.¹ Currently, there are four companies providing mobile telephone services in the country. There are also two companies providing fixed line telephone services and a host of companies providing data services as well as sale of customer premises equipment, including handsets. Further, there are a number of companies also providing value-added services, including ICT-enabled services to meet the increasing diverse socioeconomic needs of Ghanaians. With the steady growth of the economy, coupled with a sound regulatory environment, the ICT market has expanded rapidly and has become one of the best performing markets in Africa.

Mobile Telephone Network

The four mobile network operators in Ghana are MTN, Vodafone, Airtel/Tigo and Glo, with Vodafone and Airtel/Tigo as the only two fixed-line operators.

For the mobile network coverage, there are currently 2G, 3G and 4G network services. By 2016, the average 2G mobile network coverage by landmass was about 87.67%. Also, the average 3G mobile network coverage by landmass was 61.96% (NCA, 2016).

According to the International Telecommunication Union, the mobile telephone penetration in 2012 was 77% of total population. It increased to 87% in 2014 and dropped to 85% in 2016 (Figure 1). It is very difficult to assign reasons for the drop in the coverage in 2016, but it is possible that latest data might show a different picture.

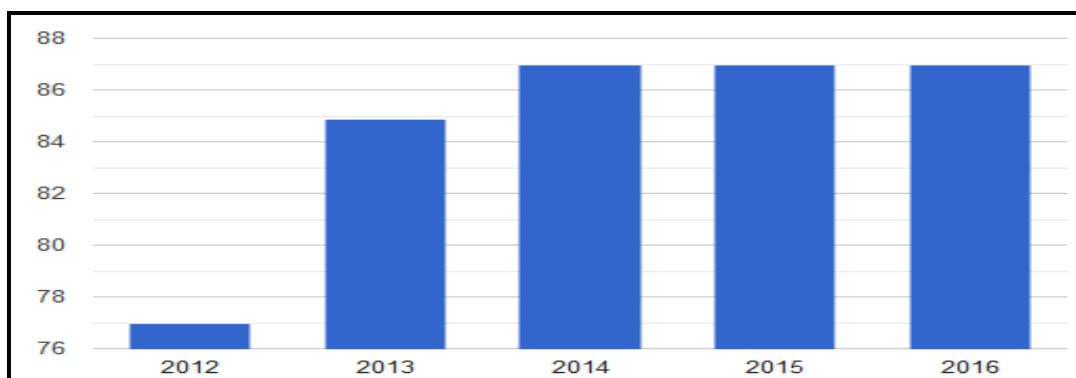


Figure 1: Ghana – Mobile network coverage

Source: www.theglobaleconomy.com, retrieved on 18th March, 2019

¹ Airtel has merged with Tigo to form one mobile network operator (AirtelTigo), while the licence of Expresso has been revoked. Data presented in this report was based on the period before the merger between Airtel and Tigo.

In terms of the individual mobile network operators, MTN has a nation-wide mobile network coverage. MTN mobile network coverage spans across all ten regions of Ghana and has the largest market share of 49 percent as at December 2018 (see Figure 2). It is followed by Airtel/Tigo with 25 percent market share, Vodafone with almost 24 percent market share. The least is Glo Mobile with almost two percent share. It worth stating that before the merger between Airtel and Tigo in 2017, Vodafone was second in terms of market share.

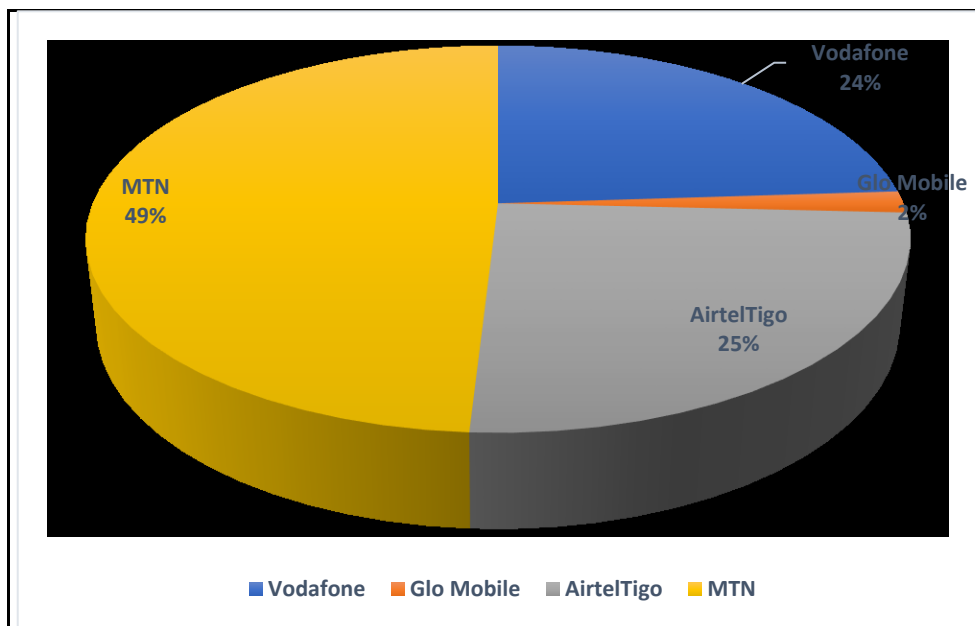


Figure 2: Market Share of Mobile Telephone Operators

Currently, MTN Ghana and Vodafone have been granted licence to operate 4G LTE (*Fourth Generation Long-Term Evolution*)² service in Ghana with an expected download speed of about 12.5MB and peak upload of about 6.25MB. There is still opportunity to award another 4G licence to any of the remaining mobile telephone companies. There is the likelihood that the purchase of the remaining 4G slot will positively impact on the already competitive pricing of 4G services being offered by the mobile telephone companies. As will be discussed later in the report, four other companies have been awarded licences to provide broadband wireless access based on LTE. In effect, Ghana has six companies providing LTE, but the dominant ones are MTN and Vodafone, due to the fact that these companies are relying on their existing infrastructure to roll out the 4G services.

Table 1: Number of unique voice subscribers (2012 – 2017)

Service providers	2012	2013	2014	2015	2016	2017
Expresso	165,863	133,663	119,059	125,263	93,599	23,264
Millicom (Tigo)	3,698,409	4,021,225	4,133,760	4,850,034	5,339,052	5,489,994
Scancom (MTN)	11,734,500	12,929,528	13,852,398	16,254,984	19,296,157	17,817,273
Vodafone	5,259,487	6,048,792	7,069,516	7,612,059	8,289,913	9,079,502
Airtel	3,192,154	3,395,263	3,735,656	4,796,645	4,591,051	4,253,993
Glo Mobile	1,568,014	1,498,011	1,450,382	1,369,402	695,306	781,022
Total	25,618,427	28,026,482	30,360,771	35,008,387	38,305,078	37,445,048
Net Addition		2,408,055	2,334,289	4,647,616	3,296,691	-860,030
% Growth		9.40	8.33	15.31	9.42	-2.24

Source: NCA; Mobile Network Operators, 2017

The total growth in terms of number of unique subscribers increased from 9.8% in 2013 to 15.3% in 2015 but dropped to 9.4% in 2016 (Table 1). The negative growth in the number of unique subscribers in 2017 could be attributed to the drastic reduction in the number of Expresso subscribers. The net addition, however, decreased by 5.9 percentage points between 2015 and 2016.

Scancom (MTN) has the highest number of unique subscribers and this confirms its market leadership, which started in 1996. One of the factors which helped Scancom (MTN) to take commanding lead of the mobile telephone market was the GSM technology it used to deploy its services (Frempong, 2007). The others, Tigo and Expresso, which were already in operation, were using analogue technology for their transmission. The intrinsic features of the GSM technology and network effect helped MTN to assume the market leadership in 1999, three years after it started operation (Frempong, 2007).

Usage of Mobile Telephones

The effective use of the existing ICT infrastructure will enable the citizens to exploit the potential benefits of the infrastructure. The effective utilisation also depends on the type of equipment used on the infrastructure.

Mobile phone ownership by socio-demographic characteristics

Table 2 provides information on the socio-demographic characteristics of mobile phone ownership in the country. Apart from female with tertiary education, more male of all socio-demographic characteristics owned mobile phones than their female counterparts. For instance, over 48% of male below 19 years and 95% of male aged 31-45 years owned mobile phones, compared to almost 40% and 84% female below 19 years and between the 31 and 45 years, respectively, who owned mobile phones. Rural men were 13.1 percentage point higher than women on mobile phone ownership (Table 2).

Table 2: Mobile phone ownership by socio-demographic characteristics

Age category	Female	Male
Below 19 years	39.6	48.1
19-30 years	88.1	94.0
31-45 years	84.2	95.0
46-60 years	78.6	90.2
Above 60 years	62.5	76.4
Location		
Urban	85.2	90.0
Rural	63.5	76.6
Education		
No Education	58.8	70.6
Basic	74.9	76.4
Secondary	91.0	94.2
Tertiary	99.7	99.2
National	76.0	83.8

Source: NCA, 2016

Types of Phone Used

There are basically three types of phones: basic, feature and smartphones³. The type of phone used has a direct bearing on the ICT services which the owner ordinarily can utilise. For example, using a smartphone can aid the use of internet and ICT-enabled services (including ICT4Ag).

³ Basic phones are types of phones that allow users to perform basic features, such as make/receive calls and send/receive text messages. In the case of a feature phone, in addition to make/receive calls, send/receive text messages, it can access the Internet and store and play music, but lacks the advanced functionality of a smartphone. Smartphone is a mobile phone that uses an operating system similar to a minicomputer and provides a variety of features, such as calling capabilities, computing capabilities, video conferencing, internet connectivity, media players and GPS navigation units.

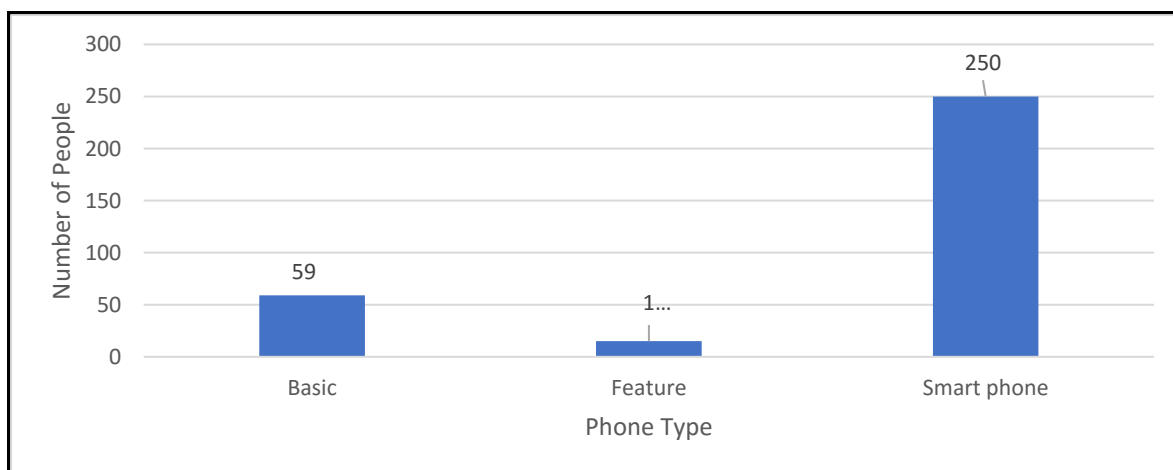


Figure 3: Type of Phones Used

From the survey carried out as part of this study, a greater majority (250 of 300 respondents) possessed smartphones (Figure 3). Though this is not representative, it shows a trend in the ownership and usage of smartphones in the country. However, in a more representative survey by Research ICT Africa among nine African countries, Ghana was second to South Africa in terms of smartphone ownership (Research ICT Africa, 2019). This is very interesting, since the smartphone enables the owners to exploit more opportunities of broadband internet and ICT-enabled services.

Table 3: Number of registered SIM cards used by respondents?

No. of Registered SIM cards Used	Urban		Peri-urban		Rural		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
One	42	41.58	49	49	41	39.42	132	43.27
Two	43	42.57	45	45	57	54.80	145	47.54
Three	11	10.89	5	5	6	5.76	22	7.21
Four	4	3.96	1	1	0	0	5	1.63
Five	1	0.99	0	0	0	0	1	0.32
TOTAL	101	100	100	100	104	100	305	100

Source: Field data, 2019

In terms of registered SIMs, most of the respondents had registered at least one SIM, but the majority had two registered SIMs (Table 3). Interestingly, more subscribers in the rural than urban areas had registered two SIM cards. The data in Table 3 showed that almost 55% of the respondents from the rural areas had two registered SIM cards. This was followed by those in peri-urban areas. The reason for this situation could be the poor quality of mobile

telephone services in the rural areas. Therefore, rural subscriber alternated with SIM cards, depending on the signal strength at a particular time.

Generally, from the three locations, most of the subscribers (almost 57%) had more than one registered SIM, but two registered SIM cards dominated. This result is confirmed by those of Research ICT Africa (2019) in where the average SIM card per subscriber was 1.4. This implies that most Ghanaians have more than one SIM card. The rationale for multiple SIMs is that they enable the subscriber to stay connected at all times, as well as to take advantage of the differences in tariffs, especially promotions offered by different operators.

Table 4: Respondents’ use of phone

Purpose	Frequency	Percentage
Calls	304	99.67
Internet	179	58.68
Social media	246	80.65
Text	169	55.40
Photos	229	75.08
Videos	206	67.54
Mobile money	253	82.95
Mobile banking	31	10.16
Games	96	31.47
Others (music, online marketing, credit transfer)	6	1.96

Source: Field data, 2019

Table 4 lists the key activities subscribers use their phones for. The least activities the subscribers used their phones for were: mobile banking, games and others (music, online marketing, and credit transfer). Activities most engaged in were making calls, social media, mobile money, videos, taking photos and browsing the Internet, and text messages. It is instructive to indicate that almost 83% of the respondents subscribed to mobile money services provided by mobile telephone companies. Subscription to these services, which is within the purview of ICT-enabled services, can facilitate the adoption of similar services in other sectors of the economy.

Mobile Internet Penetration

There were about 22,865,821 mobile data subscribers in 2017. Of this, MTN had the highest number of subscribers, accounting for 56.5%. Expresso had the least (10,151) mobile data subscribers or 0.04% of the total subscribers in 2017 (Table 5).

Table 5: Total Subscribers of Mobile Data (2G and 3G)

Service providers	2012	2013	2014	2015	2016	2017
Expresso	N/A	38180	37,331	48,178	36,672	10,151
Millicom (Tigo)	N/A	1,577,348	2,097,167	2,732,863	2,725,489	3,029,361
Scancom (MTN)	N/A	4,876,302	8,004,721	8,634,914	10,226,520	12,925,524
Vodafone	N/A	1,615,528	2,868,249	3,316,343	3,474,090	3,889,821
Airtel	N/A	1,915,300	2,130,033	2,879,431	2,902,009	2,718,966
Glo Mobile	N/A	301,283	668,424	419,459	277,372	291,998
Total	N/A	10,323,941	15,805,925	18,031,188	19,642,152	22,865,821

Source: www.nca.org.gh/assets

MTN had consistently increased its share of the internet data from 46.3% in 2012 to 56.5% in 2017. There was a direct link between MTN leadership in the voice and data markets. Most subscribers of MTN used their subscription for voice and data communication. This was usually done by bundling part of the call credits for data usage. Expresso and Glo Mobile had lost a considerable share of their market over the years. This was due to their poor performance in the rigorous competitive ICT market. For instance, from 6.0%, the share of Glo Mobile market declined to 1.3%, while that of Expresso dropped from 0.7% to 0.04% between 2012 and 2017, respectively (Table 6).

Table 6: Share of Operators of Mobile Data Market

Service providers	2012	2013	2014	2015	2016	2017
Expresso	0.74	0.37	0.24	0.27	0.19	0.04
Millicom (Tigo)	13.83	15.28	13.27	15.16	13.88	13.25
Scancom (MTN)	46.31	47.23	50.64	47.89	52.06	56.53
Vodafone	20.91	15.65	18.15	18.39	17.69	17.01
Airtel	12.24	18.55	13.48	15.97	14.77	11.89
Glo Mobile	6.04	2.92	4.23	2.33	1.41	1.28

Source: www.nca.org.gh/assets

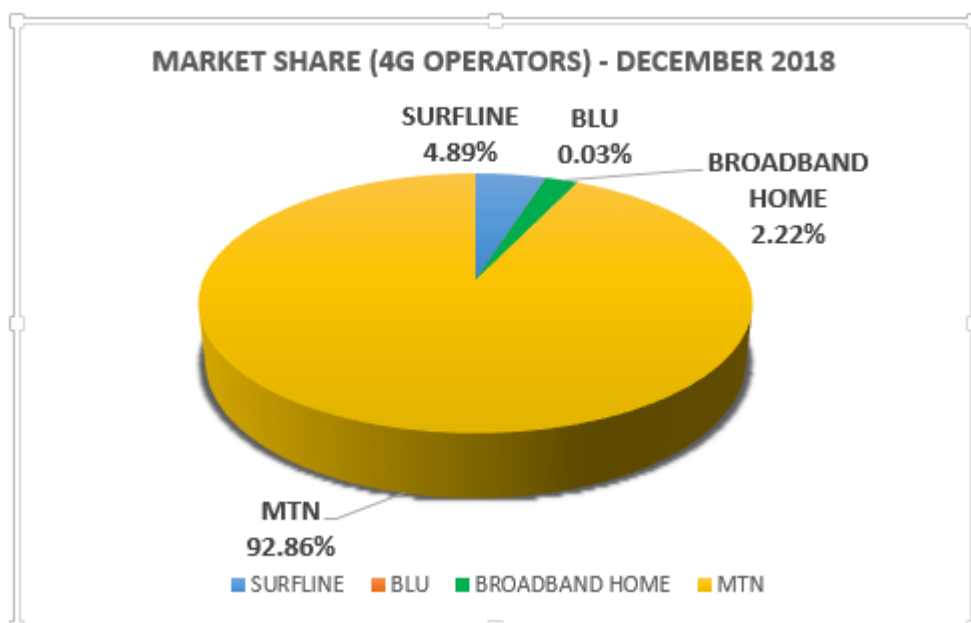


Figure 4: Market Share of 4G Data Operators

Source: www.nca.org.gh/industry-data-2

The total number of subscription for 4G data at the end of December 2018 was 1,128,498, of which MTN had 1,047,917. Surflin was second, with 55,134 subscribers; Broadband Home had 25,100 subscriptions, while Blu Ghana had only 347 subscribers⁴.

The regional variation in internet penetration was pronounced. Internet penetration was highest in the Greater Accra Region at 49.5%. The Ashanti Region has the second highest internet penetration rate at 35.0% (Table 7).

Table 7: Regional Distribution of Internet Penetration by Gender

Regions	Female	Male
Western	16.4	30.8
Central	15.9	27.9
Greater Accra	41.2	59.9
Volta	8.7	19.5
Eastern	18.5	32.5
Ashanti	27.5	43.5
Brong Ahafo	9.8	20.3
Northern	7.8	23.4
Upper East	12.5	23.1
Upper West	8.3	19.6
National	18.3	33.2

Source: NCA, 2016

⁴ Vodafone was excluded from the discussion because it was issued with 4G licence in 2018 and therefore had not commenced the provision of 4G services.

Internet Usage/ Penetration by socio-demographic characteristics

Internet usage amongst male was significantly higher at 31.0% than of female respondents, which was 18.0%. Disaggregated by age of respondents, internet usage was skewed towards the youthful population and highest among persons between 19 and 30 years (39.7%). The internet penetration rate was lowest among persons aged 60 years and above at 4.4%. Internet usage increased with level of education, rising from one percent among those with no formal education to 75% for those with tertiary level of education (Figure 5).

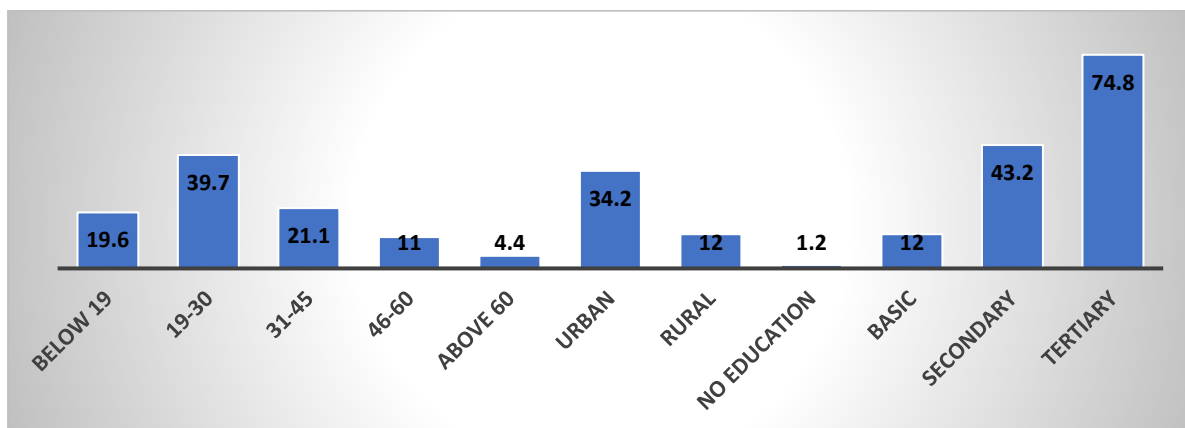


Figure 5: Internet Usage by socio-demographic characteristics

Source: NCA, 2016

The high internet usage by those with secondary and tertiary education was understandable since the use of ICT in general and the Internet in particular is knowledge-intensive; requiring some level of formal education (Frempong, 2008). It is interesting to note that these statistics are quite different from the statistics on mobile phone ownership, which are much more evenly spread across age brackets, education and rural/urban settings. One possible cause of the variation could be the cost of accessing internet services, in addition to the reason given earlier. However, this should be investigated to identify the possible causes of this variation in internet usage among socio-demographic groups.

Infrastructure

Locations of Towers/Masts

According to the National Communication Authority of Ghana, masts and towers infrastructure in the country are owned and managed by licenced tower managing companies. Identifiably, there are three tower management companies in Ghana, namely: America Tower Company (ATC), Eaton Towers Ghana Limited and Helios Towers Ghana (HGT)

Management Services Limited. Figure 6 shows the growth of masts and towers managed by these companies since 2013. The number of towers and masts across the country increased from 3,466 in 2013 to 4,271 in 2017.

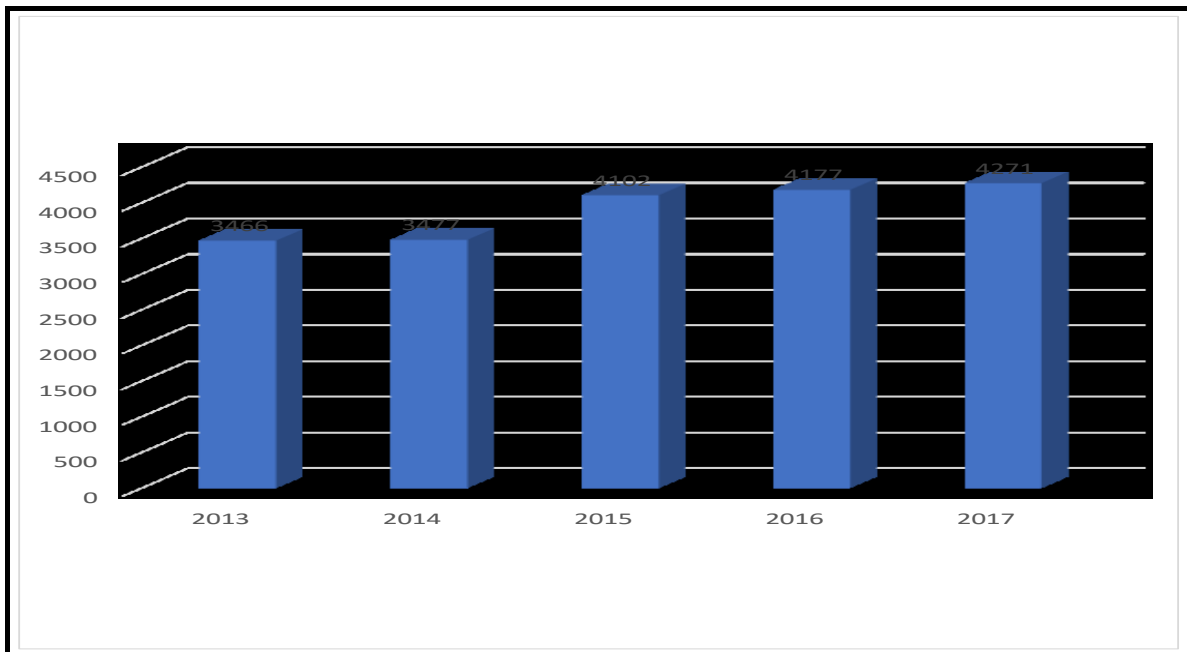


Figure 6: Total Number of Towers/Masts in the country

Source: STEPRI, 2018, Field work

The America Tower Company enjoyed majority of the market share of almost 52.0%. Eaton Towers Ghana Limited had a market share of almost 30.0%, while the rest belonged to Helios Towers Ghana Management Services Limited. These companies provided spaces for rental and offered their services on competitive basis

Quality of Service

Generally, quality of service is the assessment of how well a delivered service conforms to the client's expectations. A service provider often assesses the service quality provided to its customers in order to improve services, identify problems, and better meet clients' satisfaction. In ICT, quality of service (QoS) is the description or measurement of the overall performance of a service, such as a telephony or computer network or internet and related services.

Quality of Internet Services

An attempt was made to find out the perception of the respondents about the stability /speed (which form part of the indicators for measuring quality of service). Table 8 provides a summary of the responses.

Table 8: Analysis of responses on the stability/speed of internet access

Rating	Urban		Peri-urban		Rural		Total	
Rating	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Very good	8	10.38	3	3.03	5	6.25	16	6.25
Good	27	35.06	39	39.39	15	18.75	81	31.6
Fair	20	25.97	34	34.34	39	48.75	93	36.3
Poor	19	24.67	20	20.20	11	13.75	50	19.5
Very poor	3	3.89	3	3.03	10	12.50	16	6.25
Total	77	100	99	100	80	100	256	100

The data show that 39.0% of the sample scored the stability/speed of accessing the internet as acceptable (6.3% scored it as very good and 31.6% scored it as good). Further, almost 36.0% ranked the stability/speed of the internet as fair, 19.5% as poor and 6.3% as very poor. What the data suggest is that majority of the respondents required improvements in the quality of the internet service – the quality did not meet their aspirations.

On location basis, urban areas had relatively better signal quality (10.4% as very good and 35.0% as good). Almost 40.0% of the respondents in peri-urban areas scored the internet speed/stability as good. Comparatively, internet speed/ stability was better in peri-urban areas. It was worst at the rural areas. The state of the service in urban areas may be due to high level of usage, which perhaps created congestion in the network and, thereby, affected the speed of the internet.

Quality of Mobile Services

On the issue of reception (signal strength), less than 50.0% of the respondent scored the mobile telephone signal in their locality to be good enough (almost 9.0% rated it to be very good, while about 37.0% ranked it good).

Table 9: Rating of phone reception

Rating	Urban		Peri-urban		Rural		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Very good	15	15	1	1.02	10	9.90	26	8.69
Good	47	47	40	40.81	23	22.77	110	36.78
fair	24	24	38	38.77	40	39.60	102	34.11
Poor	12	12	18	18.36	17	16.83	47	15.29
Very poor	2	2	1	1.02	11	10.89	14	4.68
Total	100	100	98	100	101	100	299	100

Comparatively, the quality of mobile telephone services was better in urban areas than other areas. About 47.0% of the respondents scored it as good in urban areas, compared to 41.0%

for peri-urban and about 23.0% for rural areas. From this result, one can conclude that the quality of service deteriorated as one moved away from the urban areas.

Quality of service is very critical to the effective and efficient use of ICT services, whether voice or data, or any other service. In Ghana, the NCA conducts periodic monitoring services to ensure that mobile telephone operators keep to their licence obligations. The NCA sometimes sanctions defaulting operators. For example, in 2018, it sanctioned the four mobile telephone operators GHS34 million (about US\$6.8 million) for their non-compliance with various QoS obligations on coverage, data, voice and speech quality. Since most of the clients use the infrastructure of the mobile telephone operators to access such services, the monitoring exercise of NCA ensures efficiency in access to ICT-enabled services. However, the NCA mandate does not cover service quality itself (content). This implies the absence of quality control on the content of ICT-enabled services companies. Therefore, once the services of these companies do not bother on criminality, no spotlight is placed on their service content.

The critical issue is how to ensure that the services provided by ICT-enabled service providers, especially those in agriculture meet the needs and aspirations of value chain actors. One option available is to build the capacity of the users (including farmers) to self-assess service quality and then make an informed choice. Further, there is the need for a policy on this segment of the ICT industry to ensure that they meet the aspiration of users.

Submarine and Terrestrial Fibre Networks

Broadband network in Ghana has experienced some major expansion and boost primarily due to the introduction of undersea connectivity lines. There are identifiably five undersea cables in Ghana: SAT-3, the West African Cable System (WACS), Main One Cable, Glo-1 and the African Coast to Europe (ACE) fibre optic cable.

The first ever undersea cable developed in Ghana in 2001 was SAT-3, with a capacity of about 340GB per second. SAT-3 runs from Portugal and Spain to the South of the African continent. SAT-3 cable has landing points along 9 African countries along the western coast of Africa. These landing points are in Dakar-Senegal, Abidjan-Cote d'Ivoire, Accra-Ghana, Cotonou-Benin, Lagos-Nigeria, Douala-Cameroon, Libreville-Gabon, Cacucaco-Angola and Melkbosstrand-South Africa (GIPC, 2018).

The second undersea cable to be developed in Ghana was the Main One undersea cable in 2010, with an installed capacity of about 5.12TB per second. Main One currently provides a high speed bandwidth of about 1.92TB per second. Main One's network cable stretches about 7,000km along the coast of West Africa, with landing points in Nigeria, Ghana and Portugal. It is expected that with a high demand on the network cable other landing points will be developed in Morocco, Canary Islands, Senegal and Ivory Coast (GIPC, 2018).

Glo-1 submarine cable was developed in Ghana in 2011 by Globacom. Glo-1 has an installed capacity of about 2.5TB per second and stretches a distance of about 9,800km along the west coast of Africa, precisely Nigeria and UK, with a landing point in Ghana (GIPC, 2018).

In 2012, the West African Cable System (WACS) undersea cable network was established, with an installed capacity of up to 5.12TB per second. The WACS submarine cable runs from Europe through the West of Africa to the South of Africa, with a total stretch of about 14,500km interlinking 14 countries and 2 continents. WACS has undergone some expansion and upgrade to boost its installed capacity with a supplementary 14.5TB per second (GIPC, 2018).

The African Coast to Europe (ACE) fibre optic cable was developed in 2013 with an installed capacity of 5.2TB per second. The ACE fibre optic cable is estimated to stretch over 17,000km and 6,000 meters below sea level connecting about 23 countries in Europe and Africa (GIPC, 2018).

Besides the undersea fibre cables, there are a number of terrestrial fibre networks in the country. These terrestrial fibre networks are owned by both the government and the private sector. Figure 7 shows the map of terrestrial fibre networks, which traverse the length and breadth of the country, but with the majority concentrated in the south (being the most commercial area of the country).

Terrestrial In-Country Fibre for Ghana

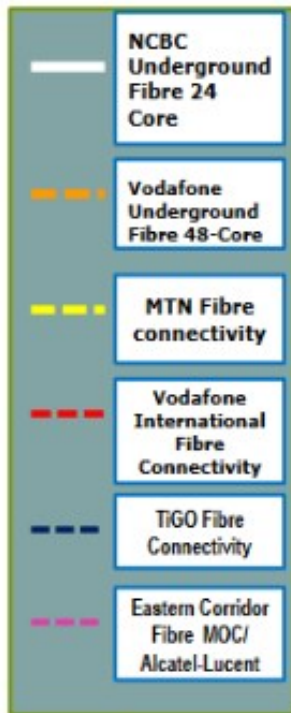


Figure 7. Map of Terrestrial Fibre in Ghana

Source: Ministry of Communications, Ghana.

Status of ICT infrastructure and innovation environment

The importance of information and communication technologies (ICTs) and their impact on socioeconomic activities cannot be overemphasised. While ICT is recognized as an important tool, access to the services by most of the people has been a critical issue. Therefore, many countries, both developed and developing, have enunciated policy and regulatory frameworks to drive the development, deployment and utilisation of ICT by the populace.

Ghana has made some strides in the development, deployment and utilization of ICT to enhance socioeconomic development. This has been achieved through the development of the necessary policy and regulatory framework to support ICT development.

The increasing importance of ICT led to its inclusion in the global Sustainable Development Goals (SDGs). Goal 9C enjoins countries to increase access to ICT and provide universal and affordable access to the Internet. As an enabler, ICT is to facilitate the achievement of other goals, such as poverty alleviation, improved health, quality education, clean energy, climate action and industry innovation⁵. Therefore, a well-developed ICT industry will play a key enabling role in the achievement of the SDGs.

Key ICT Actors in Ghana

Several institutions and organisations have been identified as key actors in the development and deployment of ICTs in the country. Table 12 provides a summary of some of the key actors in the ICT landscape.

Table 10: List of Actors in ICT Sector

Institution	Example	Role	Responsibilities
Government	<ul style="list-style-type: none"> i. Ministry of Communications ii. Ministry of Information 	<ul style="list-style-type: none"> i. Regulatory ii. Policy iii. facilitation iv. universal service 	<ul style="list-style-type: none"> i. Initiate and formulate ICT policies to stimulate the growth of ICT industry ii. Initiate and formulate regulations to support the growth of ICT industry iii. Develop appropriate regulations to protect consumers and stimulate competition in the communication sector. iv. Universal Service
Private Sector	<ul style="list-style-type: none"> Network/service providers Eg. Mobile telephone service operators Value-Added Services Data service providers (ISPs, BWA) Tower Infrastructure Companies 	<ul style="list-style-type: none"> Network development Provision of ICT plant and Equipment ICT-enabled Services Broadband internet and related services Cell sites 	<ul style="list-style-type: none"> i. Provision of ICT services ii. Development of ICT infrastructure iii. Attract investment into ICT sector iv. Provision of network and consumers' terminal equipment v. Provision of ICT-enabled Services vi. Provision of broadband internet vii. Provision of masts voice and data services Provision of facilities for co-location and facility sharing

⁵ ITU (2017). "ICT-centric economic growth, innovation and job creation". Available at: https://www.itu.int/dms_pub/itu-d/opb/gen/D-GEN-ICT_SDGS.01-2017-PDF-E.pdf?

International Regulatory Institutions	ITU, West Africa Association Telecommunications, Agencies (WATRA)	i. Regulation of global ICT industry ii. regulation of international trade	. Regional and International regulations ii. Provision of ICT Development indicators
International Development Institutions	World Trade Organisation, ECOWAS, African Union DFID, UNECA, IDRC,	Facilitation of ICT development	i Research support ii. Human resource development iii. Support provision of innovative ICT-enabled services iv. international trade regulation
Non-governmental Organisations International Non-governmental organisations	IICD,	Complementary role in ICT development Pressure group	i. ICT capability building ii. Introduction innovative services (mhealth, e-agriculture services iii. scale-up projects
Donor Agencies	World Bank, African Development Bank	Provision of funds	Financing public ICT development projects eg. E-Ghana and E-transform projects

Role of Government in ICT Development

The government of Ghana plays a dominant role in the country’s ICT development; this role involves the provision of proactive policy and regulatory environment. The role serves a dual purpose – to give confidence to the private sector (both domestic and international) to invest in the sector, as well as ensure the development of a strong ICT industry in meeting the aspirations of the citizens (both corporate and individual). To achieve this objective, the government has provided policy and regulatory frameworks as vehicles to drive the growth of the sector.

Policy Environment

The ICT landscape in Ghana is driven by two policies, namely, the National Telecommunications Policy and the National ICT for Accelerated Development Policy (ICT4AD). Before these policies, however, there was the Telecommunications Accelerated Development Plan (1994 -2000), which laid the foundation for the development of the modern ICT sector in the country.

The general objective of the Telecommunications Accelerated Development Plan was to liberalise and revamp the sector through the participation of the private sector to meet the changing needs of Ghanaians both in their social and business lives, as well as ensuring effective integration into the global context. Specifically, the plan, among others, was to:

- Ensure sustained improvement in the availability, reliability and quality of public services,
- Improve public access in rural and urban areas to telecom services through the provision of pay-phone facility,
- Expand the coverage of mobile phones,
- Liberalise ICT sector through duopoly, and
- Introduce value-added services

The implementation of the plan ushered in a plethora of services and expansion of the sector. For example, the implementation of the Plan resulted in the introduction of duopoly (initially, Ghana Telecoms and Westel)⁶ in the fixed line telephone subsector. However, the duopoly policy was not successful, since Westel was unable to meet their licencing obligation of rolling out the second fixed line telephone network in the country due to financial and operational challenges. Further, there was the licencing of mobile telephone operators (which were initially six) and this introduced competition in the mobile telephone market and underlined rapid roll out of mobile telephone services in the country (Frempong, 2004). Most of the mobile companies saw the sector as a virgin market and invested heavily to facilitate the rapid development of the market.

The Plan also facilitated the introduction of value-added services (such as data storage retransmission, teleprocessing and data processing, electronic mail service, videotext, bulk messaging, etc.) in the country through the grant of licences to these companies. From then on, the private sector became the key agent of change and invested heavily in the sector. Also, the Plan laid the foundation for the development of a modern ICT sector in the country.

The Ghana ICT for Accelerated Development Policy (ICT4AD) was launched in 2003 with the overall objective of engineering an ICT-led socioeconomic development process with the potential to transform Ghana into a middle income, information-rich, knowledge-based, and technology-driven economy (Ghana Government, 2003). The strategic focus of the policy is to support the development of the ICT sector and industry, as well as the use of ICT as a broad-based enabler to facilitate socioeconomic activities. The policy places emphasis on the development, deployment and exploitation of ICTs as engines for all sectors of the economy. The policy identified 14 priority areas (including agriculture) to drive the country towards an information and knowledge society.

The ICT4AD policy recognised the dynamic nature of ICT and provided for periodic review of the policy to take on board emerging issues in the sector. Consequently, the Ministry of Communications, based on a review in 2013/2014, introduced four key priority areas into the policy. The four priority areas are: Broadband, Cyber Security, Climate Change and Environment, and Geo-Information.

⁶ Ghana Telecoms is now Vodafone, while Westel was bought by Airtel from India.

Further, the policy provided for the development of implementation plans for the initial 14 priority areas. Implementation plans were developed for these selected priority areas but were never implemented due to lack of funds and political will.

On agriculture, the mission of ICT4AD is to modernise the agricultural sector to sustainably improve value-added and yield, and develop a dynamic and vibrant export-oriented agribusiness industry. Some of the strategies enunciated to achieve the objectives of the ICT4AD are:

- Delivering real-time information and customised knowledge to improve farmers' decision-making ability to align farm outputs with market demands and improve productivity; and
- Establishment of an agricultural information system to provide support for planning, production, storage and distribution of crops, livestock and fisheries products.

The effect of this policy has been the strengthening of the ICT Unit within the Ministry of Food and Agriculture to provide real-time information for policymaking and to stakeholders. It has led to the establishment of e-agriculture platform in 2014 to provide access to information/knowledge, services and products by stakeholders harnessing ICTs for increased agricultural productivity and resource sharing (Ministry of Food and Agriculture, undated)⁷.

The second national policy on ICTs in the country is the National Telecommunications Policy (NTP) of 2004. The NTP provides a framework within which the Ghana telecommunications sector will contribute to the achievement of the government's ICT policy vision of improving the quality of life of Ghanaians by significantly enriching their social, economic and cultural well-being through the rapid development and modernisation of the economy and society (Ministry of Communications, 2004).

Consequently, the policy provides the framework within which the telecommunications sector will contribute to the achievement of Ghana's ICT4AD vision. The specific objectives of this Policy are:

- Achievement of universal access to telephone, Internet, and multimedia services for all communities and population groups in Ghana by the year 2010;
- Fully opened, private, and competitive markets for all telecommunications services;
- Streamlined, efficient, and effective regulation of the telecommunications industry on a fully transparent, technologically neutral, and competitively balanced basis (Ministry of Communications, 2004).

No provision was made for the development of implementation plans with measurable targets. Consequently, some of the objectives are yet to be attained. For example, the objective to introduce technology neutral/unified licencing regime is yet to be realised.

⁷ There will be further discussion of the e-agriculture platform under section 2.3.1.1

However, some objectives, such as licencing of telecommunication infrastructural companies and establishment of universal service agency have been implemented. Also, the ICT market has fully been liberalised to enable many companies to provide different services to meet the socioeconomic aspirations of Ghanaians.

Legal Regime

In 2008, an array of laws were passed to bolster the development of the ICT industry. These laws are discussed below.

The National Communications Authority Act of 2008, Act 769

The Act re-established the National Communications Authority⁸ (NCA) as the central body to licence and regulate communications activities and services in Ghana. The object of the NCA is to regulate the provision of communication services in the country. The Act also empowers NCA to establish and monitor the implementation of national communication standards and ensure compliance accordingly. It is also charged with the responsibility of formulating a strategic plan; granting communication licences; regulating and monitoring licence holders of frequency authorisations, and ensuring fair competition among licensees, operators of communication networks and service providers of public communications.

The Electronic Transactions Act of 2008, Act 772

The Electronic Transactions Act of 2008 forms part of the legislation to provide a legal framework for electronic transactions. The Act provides for legislation for electronic communications and related transactions in the public interest and applies to all electronic transactions and electronic records. The Act deals with electronic transactions, electronic government services, the certifying agency and consumer protection.

The National Information Technology Agency Act of 2008, Act 771

In 2003, following the development of the Ghana ICT4AD Policy, provision was made for the setting up of a body to act as the national implementation and coordination agency for the ICT policy. The National Information Technology Agency Act of 2008 established the National Information Telecommunication Agency (NITA), with the objective of regulating the provision of ICT services to ensure the provision of quality ICT services and promote standards of efficiency.

The Electronic Communications Act of 2008, Act 775

⁸ The National Communications Authority was originally established under the National Communications Authority Act of 1996, Act 524

The Electronic Communications Act of 2008 provides for the regulation of electronic communications, broadcasting, use of electromagnetic spectrum and related matters. Under the Act, the NCA is mandated to regulate the radio spectrum designated or allocated for use by broadcasting organizations and providers of broadcasting services in accordance with the standards and requirements of the International Telecommunications Union (ITU) and its Radio Regulations, as adopted by Ghana. This Act put to rest the disagreement between the NCA and the Ghana Media Commission over the right to allocate frequency spectrum for broadcasting. The Ghana Media Commission is mandated by the constitution to oversee the media landscape of the country.

These laws and policies provide a good environment for the industry to grow by attracting foreign investors. The laws and policies have brought sanity into the ICT sector. However, the full implementation of the provisions of these laws has been slow. For example, the National Communications Authority Act and Electronic Communications Act provided for the establishment of Telecom Tribunal to adjudicate on ICT conflicts. It took the Ministry of Communications and the NCA a long time to establish the Telecom Tribunal. Though the law was passed in 2008, the tribunal was established in February 2015. Further, the National Information Technology Agency Act of 2008 established the National Information Technology Agency (NITA) and mandated it to establish regional and district offices for effective implementation of its mandate. However, these structures have not been established.

The Private Sector

The ICT sector in Ghana, until the 1990s, was largely dominated by the public sector. However, changes in the global industry and the inability of the public sector to adequately invest in the sector to enable the country to keep pace with technological development led to privatisation and deregulation of the sector. The Accelerated Development Plan of 1994 laid the foundation for increased participation of the private sector. It liberated the market, licenced mobile telephone companies, privatised Ghana Telecom, introduced duopoly and liberalised the telecom market among others. Since then, the private sector has taken advantage of the plethora of services introduced by the technological changes in the global industry.

Currently, there are five mobile phone companies: MTN (the market leader), Vodafone, Airtel, Tigo and Glo. There was a sixth company, called Espresso, but its licence was revoked in March 2018 by the NCA due largely to non-payment of regulatory fees. Also, Airtel and Tigo merged to form AirtelTigo in September 2017. These companies provide voice and data services.

In addition, there are a host of companies providing value-added services in the country. A provider of value-added service is only required to register with the NCA, but if the service entails the use of radio frequency, then it has to apply to NCA for the right to use radio frequency. Some of the companies providing value-added services are E-Transact, Esoko Ltd, Farmerline, TXT Ghana, Savannah Signatures, Tech Valley and Text Genesys Ltd. Mobile telephone operators also provide value-added services.

The private sector has taken the commanding lead in network development, provision of voice and data services, value-added services, sale of ICT equipment and related services. It also leads in broadcasting (TV and FM radio) services. For example, as at 2016, the NCA had given authorisation to 34 companies to provide broadcasting services in the country. Out of this number, only one is a public institution. In the area of broadband internet services, 52 companies have been registered (but only 25 are operational) and, with the exception of Vodafone (in which the government holds some shares), they are all privately owned. These companies provide broadband internet services in the country. It is noteworthy that most of the Internet service providers (ISPs) have turned their attention to corporate organisations, while the mobile companies have focused on both individual and corporate users. The introduction of internet-enabled telephone handsets has provided a fillip to the data services provided by mobile telephone companies. Therefore, they are the key source of broadband internet and related services for the majority of Ghanaians.

The broadband wireless access (BWA) operators provide broadband internet services using 4G (LTE) technology. Figure 4 (above) provides data on some of the 4G operators in the country. MTN controls almost 93.0% of the 4G broadband market. The other 4G operators are largely in Accra, though they are to provide services across the country.

To ensure co-location and facility sharing, as prescribed by the national telecommunication policy, three infrastructure companies have been licenced to provide such services for a fee. Their role in the ICT market is to provide the facility (masts/cell sites) for co-location, which takes away the tasks of individual telephone operators constructing and managing their own masts/cell site to provide services. The operations of these infrastructural companies should ordinarily increase the deployment of telecommunication services to unserved and underserved areas. However, this is not the case, since they deploy their services to areas which are of economic interest to the mobile companies, which are largely their customers. There are no strict regulatory obligations on the infrastructural companies in the deployment of services. In effect, their activities are underlined by pure commercial interests.

This gap of reaching the underserved and unserved areas is being addressed by rural connectivity projects of the Ghana Investment Fund for Electronic Communication (GIFEC) - the universal service agency. Under the rural connectivity projects, GIFEC provides incentive facilities, such as tax waivers on equipment, local government levies and fees, and free land for base/cell sites; and facilitates the acquisition of permits for the projects.

Facility sharing is not limited to base station/cell sites, but is extend to fibre networks owned by the individual mobile telephone operators. The operators offer for sale excess capacity in the fibre network on purely commercial basis. While this reduces redundancy in a given network, it also helps other operators to improve their quality of service or extend their coverage.

The sale of ICT equipment is also in the domain of the private sector. In terms of network and infrastructural development, all the mobile telephone companies have constructed their own terrestrial fibre networks to provide high quality data and voice services in the country. However, fibre networks are largely concentrated in the southern part of the country.

There are also private companies which provide ICT-enabled services in the country. These companies need not obtain authorisation from NCA if their operations do not require the use of frequency but ride on the back of other authorised companies. The ICT-enabled service providers assist users to access value-added services in specific disciplines/sectors, such as health, agriculture, meteorology, extension services and market information.

International Organizations

Boxes 1 and 2 provide a summary of the contributions of international organisations, development partners and NGOs (both local and international) to the development of the ICT sector in the country. (See Appendix 1 and 2 for more information on the services.)

Box 1: Plan International Ghana

Plan International Ghana has implemented Community-based ICT programmes targeted at improving education. Since 2017, Plan has implemented the ASANKA project in five (5) communities (Boli, Sing, Busa, Baleufili, and Nyoli) in the Upper West Region in two districts (Wa Municipal and Wa West Districts) with technical support from TECHAiDE.

ASANKA is a free Information Access System that works without the internet but like the internet. It is cheaper, faster, easier to access the content, and can be customised. You can track changes over time with surveys, interactive quizzes and games to see how people improve performance and achieve results. The content of the 1Watt device can be assessed by any enabled Wi-Fi device.

The concept of ASANKA is to digitalise teaching and learning content for improved performance, promote internet access in remote areas at low cost, and to make educational materials available in working libraries in remote schools. Free resources in ASANKA include the GES syllabus for every level, the whole of Wikipedia for schools, and other books and videos pre-installed. These contents cover agriculture as well.

The ASANKA system allows users to upload their own contents onto the device or to a cloud account which is later synced to the device via an earth net port. Currently, six (6) different compatible formats can be uploaded: video files, audio files, static documents (word, excel, pdf, PowerPoint etc), interactive quizzes, surveys (as a learning tool), and interactive games. The project offers the following solution

- Browse videos, audios, pictures, documents and play interactive games using smartphones, tablets, and laptop at low cost.
- Good connection in remotest areas.
- 20 different people can connect to one ASANKA Wi-Fi (1 box) without affecting the speed.
- The cost per box is USD150, which is paid by Plan International.
- 1 terabyte of storage available for sharing your own content; and
- Content can be broadcast using projectors, audio speakers etc.

Box 2: Literacy Bridge

Literacy Bridge (LB), started in 2007, is an information disseminating organization, relying on the Talking Book technology. The organization has worked on various projects for UNICEF, CARE International, MEDA, AGRA and Winrock International over the years with a vision of a world where life-changing information and technologies are available and accessible to all, especially the most vulnerable. Literacy Bridge strives to empower the most underserved and poorest people and communities with accessible and quality information and skills in a way that leads to understanding and behaviour change, and improved health, incomes, and quality of life.

A technology which has been facilitating the work of Literacy Bridge is the Talking Book. The Talking Book is the world's most affordable audio computer designed specifically for people who cannot read and who live without electricity. The device speaks to the user in their mother tongue. The Talking Book does not require grid electricity but uses batteries that people are already using in their torches and radios. The Talking Book is powered by a pair of dry cell batteries of 1.5 volts each. A pair of batteries last roughly a week after active group listening. Literacy Bridge utilizes the Talking Book to reach hard-to-reach populations, whose needs are often unmet by traditional public health and agricultural outreach efforts, given their geographical remoteness, lack of literacy skills and resources.

The World Bank has over the years provided financial and technical support for the development of the ICT sector in the country. More recently, it funded the e-Ghana and e-Transform Projects, which are critical to developing national infrastructure to support e-government activities.

The e-Ghana project was to assist the government to generate growth and employment using ICTs and public-private partnerships to: develop the IT-enabled services industry and contribute to improved efficiency and transparency of selected government functions through e-government applications. The project was funded by the World Bank in 2006 and ended in 2010. One of the initiatives of the project was the establishment of IT-enabled Services Secretariat to drive the development of and support for IT-enabled service providers in the country. It also laid the foundation for the establishment of ICT Park in 2012.

The e-Transform is a follow up of the e-Ghana Project. The development objective of e-Transform Project is to improve the efficiency and coverage of government service delivery using ICT. The project activities are to be realigned with government developmental priorities. The components of the project include: creating an enabling environment for e-government and e-business; supporting the upgrade of national identification system and online verification services; and scaling up of applications to improve service delivery in priority sectors. The project is ongoing and will end in 2020.

Largely, the e-transform project is directed at building national public service delivery systems. The ongoing National Identification Card (Ghana Card) registration is one of the

components of the project. However, e-Ghana had strong private sector focus and this is evidenced in the establishment of IT-enabled Service Secretariat to support such businesses.

Furthermore, international development partners, such as the Danish Development Agency (DANIDA), DFID United Nation Economic Commission for Africa and International Development Research Centre of Canada (IDRC) have contributed towards building human capital, research and development, and direct support to government in relation to ICT development. Although the support from these agencies have been crucial, the government has not been able to sustain the projects once the funds from the development partners ceased. This has negatively affected the long-term benefits of their interventions. For example, UNECA facilitated the acquisition of financial support for the development of Ghana's ICT4AD Policy. The government could not, however, implement the rolling out plans underlined in the policy document when the donor support ceased.

ICT Infrastructure

The various national policies (Accelerated Development Telecommunication Plan, ICT4AD and National Telecommunication Policy) have provided an enabling environment for ICT infrastructural development. This section discusses salient issues in ICT infrastructural development.

Licencing Regime

The Electronic Communication Act mandates every company providing public communication services to obtain a licence from NCA. However, technological development is radically changing the licencing regime of communication services and introducing new dimensions into the sector in terms of the scope and what should be licenced. This is a daunting task, as regulation has always lagged behind developments in the market; but a more proactive licencing regime may make an impact in terms of reducing the gap in the pace of technological development.

The new development in the licencing environment, which is yet to be implemented in Ghana is unified licence. The import of unified licence is that the licensee can introduce new services without recourse to the regulator for a fresh licence. For example, mobile telephone companies can enter into the broadcasting market without recourse to a new licence. The discussion on the issuance of unified licence is long overdue. It is hoped that the Ministry of Communications and the NCA will expedite actions on the issuance of this licence.

Co-location and Facility Sharing

Facility sharing has become a very important regulatory issue in the country, as it addresses the public uproar over the unplanned nature of mast construction. It also helps to reduce cost of extending services to new areas or improve quality of service. NTP supports facility sharing as a measure to bolster fair competition, minimise cost and public inconvenience, and protect

the environment. The policy stipulates that, as far as possible, access to public rights-of-way, towers, telephone poles, underground conduits, international cable landing stations, and other physical support structures should be shared among operators (Ministry of Communication, 2004). NCA was to play a key role in the negotiations of terms and conditions, including cost allocation, for such shared facilities.

As already mentioned, to operationalise the infrastructural sharing, NCA licenced three companies (American Towers Company (ATC), Eaton Towers (Ghana) and Helios Towers (Ghana) Managed Services Ltd). These companies have taken over the management of cell sites and masts owned by the mobile telephone companies, and the mobile telephone companies now rent spaces from the ICT infrastructural companies. The licencing of the infrastructural companies has reduced the tension associated with facility sharing, as well as scramble for space by individual mobile telephone companies to construct their masts/cell sites to either increase access or improve quality of service. With the operations of these infrastructural companies, mobile telephone operators only rent spaces on the masts to mount their antennas/equipment to provide services to new areas. This invariably reduces the cost of introducing a service to a new area so as to improve access for users.

Broadband Access

Broadband infrastructural development is led by both public and private sectors. Within the private sector, mobile telephone companies are leading in the deployment of broadband networks in the country. MTN has the largest network, with about 52.0% coverage but basically concentrated in the commercially viable areas of the south. The deployment by other operators has followed similar pattern.

The government of Ghana is playing a complementary role in broadband infrastructural development and deployment. The national fibre network (e-government network) managed by National Information Technology Agency (NITA) serves as complementary to the commercial fibre. The Eastern Corridor fibre network is designed to reach up to 1050 sites around the country; 550 locations via wireless last mile access networks and an additional 500 locations through various terrestrial connectivity options. The first phase (Ho to Bawku) was commissioned in 2014, while the second phase (Ho to Accra) was completed in 2018. One important element of the government's intervention is the provision of infrastructure to the underserved regions of the country.

Also, Vodafone Wholesale operates a fibre network, formerly owned by the Volta River Authority, that was included in the package of Ghana Telecoms sold to Vodafone. The fibre network forms a ring connecting major towns in the south and extending to Tamale through Sunyani, Techiman and Buipe.

Another development to facilitate the deployment of broadband services is the issuance of broadband wireless access (BWA) licences by the NCA. The key reasons for this issuance of

BWA licence were to enhance competition in the broadband space and accelerate the bridging of the urban-rural divide in the access to broadband services. Currently, these companies (Broadband Home, BLU, Surfline, Busy and Telesol) have been issued with BWA licences to provide broadband internet and related services in the country. This is to increase broadband access to enable the country to achieve the vision of ICT4AD of developing an information-rich and knowledge economy (Government of Ghana, 2003). These companies are currently operational but, as already mentioned, are largely in the commercial areas of Ghana.

Further, MTN and Vodafone, which are the two companies with significant market power, have been granted 4G licences (Fibre to the Building) and currently available in commercially viable areas and largely driven by profitability and competitive advantage. Though this has a positive effect of increasing the country's broadband internet penetration, it may negatively affect the businesses of traditional Internet service providers (ISPs). The mobile telephone companies will compete with ISPs for customers, especially the non-corporate subscribers who may be attracted by the low cost to using the data service facilities provided by mobile telephone companies. One advantage the mobile telephone companies have is their wide coverage, which enables people to access broadband internet anywhere their signals are available.

Further, Internet Service Providers (IPS) in Ghana have established an internet exchange point to route all their traffic to the outside world. Though this is laudable, it has not achieved its intended purposes, since a few Ghanaians have subscribed to the *.gh* domain name. A large percentage of internet users have subscribed to websites which are hosted outside the country and, therefore, such traffic is not routed through the local internet exchange point.

Conditions for stimulating development and impact of ICT-enabled services

The existence of favourable conditions is very important for the deployment and growth of every business. Mainstreaming ICT into businesses (including agribusiness) has underlined the introduction of many services, which should be supported to grow through the provision of a conducive environment.

Service provision

Agricultural growth can be facilitated through the provision and adoption of ICT-enabled services to provide access to the market, input supply, extension services, agricultural best practices and financial services, among others. Therefore, this section looks at some key indicators in the provision of ICT-enabled services.

Sectorial Policies

The national ICT4AD Policy identified agriculture as one of the priority areas which ICT can be mainstreamed to enhance the development of the sector. ICT is to be used to modernise

agriculture and address climate change issues, which have direct impact on agriculture. One of the key objectives of the ICT4AD policy for agriculture is to establish a robust, diversified and commercially based agricultural sector that ensures food security and supply of adequate raw materials to industry, and contributes to export earnings, among others.

Further, ICT has a role to play in achieving the objectives of the Ministry of Food and Agriculture. In recognition of this role, the Ministry has set up two ICT-related departments: ICT Unit, and E-Agriculture Resource and Call Centre. The ICT Unit has been in operation since 1980, while e-Agriculture Resource Centre was established in 2011 with the support of World Bank. These two units are to drive the integration and mainstreaming of ICT into the modernisation of the sector. The objectives of ICT Unit are: to use ICT to ensure food security and knowledge management; develop and adapt relevant agricultural content for poverty alleviation; and develop global trade and business opportunities for farmers, among others.

The e-Agriculture Resource Centre provides access to information/ knowledge, services, and products by stakeholders through the exploitation of ICT for increased agricultural productivity and resource sharing. Specifically, the Resource Centre develops or acquires ICT applications to collect, collate, store, archive and share information. The Centre also helps improve access to and dissemination of information to farmers and other stakeholders. The Centre also promotes and facilitates the establishment of public-private partnership in the collection and dissemination of agricultural information within Ghana.

Programmes established under the e-agriculture resource centre include:

- e-agriculture portal
- interactive voice response
- resource and e-learning centre
- multi-Directorate call centre
- resource centre
- e-field extension service delivery
- e-subsidy management for fertiliser

These projects hopefully will contribute to increasing access to critical information/ knowledge to help farmers improve productivity. However, the question is: How can the majority of smallholder farmers access e-agriculture facilities? Smallholder farmers dominate the agricultural sector of Ghana and are largely illiterate. However, certain level of literacy is required to effectively use these facilities. Notwithstanding, in 2014, e-field extension platform attracted over 40,000 active subscribers and an average of 2,000 farmers accessed information each day on their standard mobile phones with local languages, including Twi, Ga, Ewe, Nzema, Dagbani and Gruni.⁹ Though this data is old, it points to the interest in the

⁹ <http://www.ghana.gov.gh/index.php/media-center/news/570-government-develops-24-7-free-call-e-extension-platform> data retrieved on 5th June 2019.

service and also signifies the relevance of the information/knowledge being acquired from the platform.

Innovation Spaces

In the contemporary world, economic innovation has become critical in supporting competitiveness in the global economy. Many developed and developing countries have created innovation spaces where innovative ideas can be supported and nurtured to fruition. An example of such innovation spaces is the Silicon Valley in USA, where start-up companies conglomerate and grow to become leading companies in the world.

Business incubators are initiatives to stimulate and support economic growth by promoting the creation and development of innovative companies. The primary goal of the incubation process is to support entrepreneurs and businesses being promoted to become competitive.

A number of incubation facilities have been established by both the government and the private sector to provide largely specialised ICT-enabled services to support socioeconomic development. Ghana Multimedia Incubator Centre was established in 2005 through a collaboration between UNDP and the Ministry of Communications. The incubator supports start-ups and young businesses with innovative ideas in ICTs to grow and mature into viable business ventures. As part of the incubation, the centre provides office space, utilities, internet access and a shared resource centre which provides various secretarial services. In 2016, MTN Ghana Foundation sponsored 10 new start-up businesses for two years to develop their innovative ICT ideas at the Centre.

Another incubation facility is the Accra Digital Centre. The Centre is to create a conducive ecosystem for digital innovation and entrepreneurship among the youth in Ghana. It is funded by the World Bank and Rockefeller Foundation to provide incubator space, which consists of office suites, virtual offices for rent and business development programmes for start-ups and other companies.

Meltwater Entrepreneurship School (MEST) is the leading private pan African incubation facility in Ghana. It provides entrepreneurial training and extensive hands-on project work. Typical as an incubator, it provides working space, hands-on support, and advisory services, among others, to the incubatees. MEST has financially supported and invested in over 25 early stage software companies, and industries ranging from e-commerce and consumer internet to agritech, fintech, healthcare IT and digital media.

There are also numerous hubs established by the private individuals and organisations to provide ICT-enabled services to different segments of the Ghanaian economy. Some of these hubs are Farmerline, Kosmos Innovation Hub, Cocolink, VotoMobile, Ispace Foundation, Hapaspaces, Vodafone Farmers' Club, and MTN's mAgric. These hubs serve as platforms for the development of general business innovative services, including agriculture. For example, Cocolink is a mobile technology platform or service that provides appropriate farming, social and marketing

information to cocoa farmers in selected communities of Ghana. The objective is to improve income and livelihoods of farmers. Cocoa farmers who subscribe to Cocolink receive and share practical information through SMS and voice messages with industry experts and other farmers.

Though there has not been a systematic or scientific assessment of the impacts of these hubs on start-up development, there is evidence of their support for start-up companies. Several incubatees from Meltwater Entrepreneurial School have, for example, graduated to set up their own companies.

Financial Incentives and Support System

There are many and varied sources of funds for start-up companies and these can be formal and informal. Informal sources include family support, personal savings and friends. Until recently, this had been an important source of funding for start-up companies in the country. Formal sources are mainly financial institutions or financial programmes established by government or NGOs.

There are a number of fiscal incentives available in the country, but they are largely for medium and large-scale companies. They include reductions in corporate income tax, exemption from import duties and tax reliefs. There is also an incentive whereby the tax losses of a company are carried forward for five years. However, only companies registered with Ghana Investment Promotion Centre are eligible for such incentive. In effect, small-scale ICT start-up companies cannot benefit from such incentives. There is also reduced corporate tax from 25 to 22%, but this is also applicable to companies registered on the Ghana Stock Exchange. In the ICT sector, only MTN qualifies for this incentive, being the only ICT company listed on the Stock Exchange. Further, companies registered with the Free Zone Board enjoy reduced corporate tax from 25 to 15% for 10 years.

There are more incentives to companies provided by GIPC under what it terms as priority investment areas. The priority sectors are energy, infrastructure, agriculture, agribusiness, manufacturing, oil and gas, tourism, and services (including ICT). However, the qualifying financial threshold for a company is US\$50 million. The applicable incentives and benefits can be found in Section 26(4) of the GIPC Act, 2013, Act 865.

As mentioned earlier, companies listed on the Stock Exchange and registered at the GIPC are well-established with high capitalisation. However, none of the start-ups can be registered with the named institutions. Therefore, ICT-enabled agricultural services, by scale, cannot benefit from these fiscal incentives.

To address this gap, the government established the National Entrepreneurship and Innovation Plan (NEIP) in 2017 as a flagship policy initiative to support start-ups and small-businesses in the country. The NEIP primarily focuses on providing business development

services, start-up incubators and funding for young entrepreneurs to enable them to grow and become successful.

Start-ups and small-businesses registered under NEIP enjoy tax reliefs, based on location of their businesses. The reliefs range from 5% to 15% for a five-year period after the initial concession. For example, a business located in Accra and Tema attracts a tax relief rate of 15%, while that sited in the northern part of the country attracts 5%. The young entrepreneur (under the age of 35 years old) may carry forward loss of tax for 5 years. The NEIP is, however, in its formative stage and requires time to make significant impact.

There is also the Venture Capital Trust Fund which is to provide finance to small and medium enterprises (SMEs). It is to promote and support the private sector to grow so as to help achieve the development targets of the country through long-time funding to SMEs. As part of its operations, it has established the Ghana Angel Investor Network (GAIN) to provide capital for early stage entrepreneurs. The network also provides a platform for accomplished entrepreneurs to partner young entrepreneurs to tap into business opportunities springing up in the country.

End User Access

Users' access to ICT services is very important, since their uptake of the services means that their impact is being felt in the socioeconomic spheres of the country. This section discusses some of the factors that increase user's access to ICT services.

Universal Service Fund

The Ghana Investment Fund for Electronic Communications (GIFEC) is the universal service agency of Ghana and was re-established by the Electronic Communications Act, 775, 2008. It serves as one of the strategies for bridging the digital divide between the urban and rural areas, the served and unserved areas of the country. Through its projects, GIFEC focusses on last mile approaches for serving the rural and underserved areas of the country. For example, the Rural Telephone Project, in addition to voice communication, provides second generation (2G) base stations with small cellular antennas, which provide free internet WI-FI services. Other projects are Cyber laboratory, Community Communication Centre, ICT education, awareness and content and ICT for livelihood. ICT for livelihood has special projects on sustainable fishing, digital inclusion and smart community project.

Over the years, 429 Rural Telephony sites have been built and a further 300 internet points of presence supplied. Though the impact of these interventions has not been considerable, they have lowered the urban-rural divide. A survey by Research ICT Africa in Ghana among selected African countries revealed an interesting story about locational disparity in terms of access to the internet. Ghana's location disparity stood at 62.0% in 2008 and declined to 55.0% in 2012 but increased to 57.0% in 2017 (Research ICT Africa, 2019). It can be argued that GIFEC's activities have made some impact in the access to ICT services, since their

infrastructure have enabled farmers to tap into ICT-enabled agricultural services to support their farming activities. However, much remains to be done to make their interventions significantly felt in the rural areas. For example, the original objective of making community information centres, information clearinghouses (including agriculture) and ICT training centres are yet to be realised.

ICT Pricing

Pricing is an important component of ICT access and usage. An unattractive pricing mechanism will affect the capability and enthusiasm of operators to increase investment in improving the deployment and expansion of ICT services. On the other hand, if the pricing is too high, it may deter consumers from effective use of the services. Consequently, there is the need to achieve synergy between social good and economic interests of ICT companies.

Pricing of ICT services, especially voice and data, had some interesting turns in Ghana. Most of the operators, especially the mobile phone companies, have adopted a combination unit price and bundle approach. For MTN, the normal call charge on MTN Cool has the on-net call charge of GHS0.1103 per minute, while the off-net charge is GHS0.1365 per minute. It also has MTN Zone whose on-net rates depend on the zone that a subscriber is at a particular time of the day. There are several other bundles, as shown in Table 13. The subscriber of a bundle would have airtime for voice and data (SMS and internet).

Table 13: MTN Super Saver Bundles

Package	Price (GHS)	Validity (Days)
50 mins- MTN	5	30 Days
10 mins- non MTN		
15 SMS – MTN		
5 MSS – non MTN		
100 mins – MTN	10	30 Days
20 mins – non MTN		
40 SMS – MTN		
10 SMS – non MTN		
200 MB		
400 mins - MTN	50	30 Days
100 mins – non MTN		
60 SMS – MTN		
40 SMS – non MTN		
2 GB		
1000 mins – MTN	150	30 Days
500 mins – non MTN		
150 SMS – MTN		
50 SMS – MTN		
6 GB		

Therefore, it is more cost-effective to sign onto these bundles for effective utilisation of airtime. Table 14 provides the price plans of AirtelTigo, which is the second largest network in Ghana. Table 15 shows the various bundles of AirtelTigo and their prices. One interesting aspect of the AirtelTigo bundles is their non-validity nature; hence, they are appropriate for users of ICT4Ag services.

Table 14: AirtelTigo Tariff Plans

Voice: Price Plan	AirtelTigo On-net	Off-net	Data MB/Pesewa
Talk and Browse saa	0.120	0.120	0.10
Kasa saa	0.168	0.168	0.56
Legacy	0.120	0.120	0.16
Chaw chaw	0.138	0.174	0.20
Double value	0.138	0.174	0.20

Source: <http://www.airteltigo.com.gh/airteltigo-new-tariffs/> retrieved on 4th April, 2019

Table 15: AirtelTigo Big Data Bundles

Bundle	Price (GHS)
25MB	0.5
65MB	1.0
150MB	2.0
550MB	5.0
1.5 KB	10.0
4 GB	20.0
10GB	50.0

Source: <http://www.airteltigo.com.gh/airteltigo-new-tariffs/> retrieved on 4th April, 2019

Table 16 shows the price of 1GB data as a percentage of personal income of selected African countries. In 2015, the cost of 1GB of data in Kenya was 9.72%, the highest among the selected countries. It dropped to 4.33% in 2016 and further to 4.01% in 2017. In Ghana, there were no significant changes in the prices of 1GB of data. One GB data represented 3.89% of income in 2015, 4.11% in 2016 and then to 3.56% in 2017.

Table 16: 1GB Price as a Percentage of Income

Country	2015	2016	2017	Average
Ghana	3.89	4.11	3.56	3.83
Kenya	9.72	4.33	4.01	5.87
Nigeria	6.54	1.57	1.59	3.32
Cote d'Ivoire	7.01	6.36	7.23	6.87
Senegal	5.23	3.87	10.2	6.43

<https://a4ai.org/mobile-broadband-pricing-data/> Retrieved on 14th February, 2019

In all, it was in Nigeria that there were significant percentage changes in the income spent on 1GB data. The price of 1GB as percent of income dropped from 6.54 in 2015 to 1.57 in 2016 and marginally increased in 2017 to 1.59. From the data, In Nigeria, consumers spent less of their income on 1GB data in 2017; this was followed by Ghana and Kenya. The most expensive countries were Cote d'Ivoire (7.23%) and Senegal (10.2%) for the same period.

Consumer protection

Consumer protection is essential in building the confidence of consumers; it is also an avenue to seek redress when the need arises. One of the functions of NCA is to ensure consumer protection from all forms of abuse from the telecom operators, ISPs and value-added service providers.

To protect consumers, NCA undertakes periodic quality assessment of the services of mobile telephone providers and imposes penalties on operators whose services fall below acceptable standards. However, the monitoring does not cover the traditional data service providers (ISP); hence, they do not sanction the latter when their services fall below expectation. The argument is that the internet market is self-regulated and, therefore, market dynamics should be allowed to lead the sector. This argument was accepted during the initial development of market where quality of service indicators and measurement were new. However, with market growth, it is important that the regulator and Ministry of Communications revisit this policy.

Generally, there is low sensitisation on consumers' rights largely due to the absence of vibrant consumer-focused civil societies in the country. Also, the relatively high level of illiteracy has affected the extent to which customers report to the appropriate authorities when their rights are abused by service providers. For example, the NCA has established a platform on its website for people to lodge their complaints. This laudable effort is, however, beyond the reach of ordinary Ghanaians who have little or no knowledge of the existence of such facility.

Data Privacy

Data in this contemporary world has attracted much attention, mainly because the global digital economy hinges on the access and availability of data. Therefore, the concept of big data has been developed to emphasise the importance of data. Various national, regional and international data regulations epitomise this point.

In Ghana, there is the Data Protection Act of 2012 (Act 843) which established the Data Protection Commission. Ghana is thus one of the few countries in Africa with a data protection law. The key object of the Commission is to protect the privacy of the individual and personal data by regulating the processing of personal information. The law provides the process to

obtain, hold, use or disclose personal information. There is no specific provision in the Act on ICT-enabled services, but the general provisions of the Act apply to these companies since they handle data on subscribers.

The Act provides avenue for an aggrieved person (ICT user) to seek redress in the law court. The critical issue, however, is: How many Ghanaians know the existence of this law and the work of the Commission? The work of the Commission has not been effective in conscientising Ghanaians on data privacy issues. There is a constant abuse by mobile telephone companies through the sale of customers' mobile numbers to bulk SMS providers to bombard them with unsolicited adverts. However, nobody (including Data Protection Commission and NCA) has taken a legal action against the mobile telephone companies for the abuse of privacy of consumers through the sale of customer contacts to third parties without their consent. This points to poor knowledge on data privacy issues in the country.

Intellectual Property Rights

Ghana has put in place the legal framework to facilitate and protect intellectual property rights activities in the country. There is the Copyright Act, 2005 (Act 690) which established the Copyright Office with the mandate to, among others, implement copyright and related laws, regulate and provide for copyright administration, investigate and redress cases of infringement of copyright, and settle disputes of copyright where those disputes have not been reserved for settlement by the Copyright Tribunal. One segment of Ghanaians who are critical about the copyright issues comprised those in music and creative arts industry. They have formed associations to ensure that users of their creative works pay them for utilising their services.

There is also the Patents Act, 2003 (Act 657) which provides for the protection of inventions and other related matters. In addition, the government has enunciated the National Intellectual Property Policy and Strategy (NIPPS) to effectively harness and manage the intellectual property system in Ghana.

The lack of awareness of the legal rights and protection provided by IP regime in the country to register intellectual property has drastically minimised patronage of intellectual property registration by small and medium-scale enterprises and individuals in Ghana.

E-skills Development

Agreeably, ICT is knowledge-intensive and requires certain level of literacy and numeracy to effectively appreciate and use. Consequently, the national ICT4AD policy identified human resource development in ICTs as one of the priority areas to help the country build the requisite ICT skills to support a knowledge-based economy.

Further, the Ministry of Education in 2007 developed the ICT in education policy, which provides guidelines in using ICT to facilitate teaching and learning, as well as equip students

with ICT skills. Under this policy, ICT education was introduced into the curriculum of both basic and second cycle schools. Various programmes supported by development partners in the past have been introduced into the second cycle institutions to support ICT teaching and learning. Examples are Microsoft Partners in Learning Programme, NEPAD e-Schools Initiative, CISCO Academy, and Global Teenager Project and Oracle Academy Initiative.

Further, under GIFEC, second cycle institutions in rural and deprived communities have been supported with computers with internet connectivity. Between 2014 and 2018, about 620 second cycle schools benefitted from GIFEC's School Connectivity Project. One main setback in this intervention was the issue of continuity. Typical of a donor-funded project, the project died immediately donor funds cease.

In spite of these initiatives to build e-skills right from the second cycle level, there remains a gap which has to be filled. A study by the International Finance Corporation (2019) revealed that Ghana has a shortage of intermediate and advanced digital skills to meet the increasing demand for such skills required by Ghanaian businesses. If this gap is not addressed, it will negatively affect the competitiveness of these firms in the global market.

Taxation

One tax which has direct bearing on users is the communication service tax (CST). The tax is imposed on all users of services provided by communication service providers, excluding those of intra-organisational communication services (private networks). This tax is 6% of the charge of service providers when utilising their services; this is collected by the service provider and paid monthly to the Ghana Revenue Authority. The businesses in this category include:

- National fixed network and mobile cellular network operators
- Internet Service Providers (ISPs)
- Public/Corporate Data Operators
- Providers of Radio (FM) broadcasting services
- Providers of Free-on-air and Pay-per-view television services

The introduction of CST in 2006 resulted in the removal of import duty, VAT and National Health Insurance Levy (NHIL) on the importation and sale of telephone sets, including mobile or cellular phones and satellite phones. Though the removal of these taxes was to make these telephone handsets affordable, it has rather increased the cost of usage. This is because payments of import and other duties on handsets are one-time payments, while CST is a continuous one and has negative implication on increased use of electronic communication services. In other words, the customer pays CST any time he/she uses an electronic

communication service. In this case, it will negatively affect farmers who want to exploit the potentials of ICT-enabled agricultural services. Generally, farmers and other value chain actors in Ghana are smallholders and normally considered poor due to the limited returns from their activities. Therefore, the imposition of CST will affect their effective use of ICT-enabled agricultural services, which they might require to improve their productivity.

Last Mile Effect

Although it is estimated that the digital economy will grow at 18.0% per year in developing countries, over 4 billion people globally still do not have access to the Internet¹⁰. Increasing access to ICT and ICT-enabled services requires the existence of efficient last mile technologies. The last mile connectivity, in the context of telecommunications, refers to the technology providing connection services to and from the user's premises¹¹ through different technologies, such as cables and wireless. This is an infrastructural issue in terms of providing access; but there is another dimension: last mile, in terms of the existence of capability to use ICT services (for example, digital literacy, affordability, speed, and quality of service).

In Ghana, there are limited digital skills. As discussed earlier, a study by International Finance Corporation indicated that Ghana lacks intermediate and advanced digital skills to provide support for businesses. Further, Research ICT Africa (2019) revealed that 14.0% of Ghanaians are digitally illiterate; in effect, they cannot use ICT-enabled services or ICT4Ag services to enhance their socioeconomic activities even if the physical last mile connectivity is available in their community.

Another element directly related to the use of the last mile connectivity is affordability. According to Research ICT Africa (2019), Ghana is among African countries with low rates for 1Gb internet data. The cost of 1Gb data in 2016 in Ghana was USD2.24, Mozambique was USD 2.01, while South Africa, being the most expensive, was USD7.84. However, the key reasons for not using the Internet in Ghana were affordability and lack of awareness (Research ICT Africa, 2019). Data services are not regulated in the country; market dynamics/forces determine prices. Thus to achieve effectiveness in this pricing system, there is the need to ensure that prices are affordable, especially to the vulnerable in the rural areas.

¹⁰ <http://inclusion.digitaldevelopment.org/last-mile-connectivity-initiative>

¹¹ <https://www.techopedia.com/definition/26195/last-mile-technology>

Status of ICT4Agriculture Services in Ghana

Introduction

Agricultural growth can be facilitated through the provision and adoption of ICT-enabled services to provide access to the market, input supply, extension services, agricultural best practices and financial services, among others. The national ICT4AD Policy identified agriculture as one of the priority areas which ICT can be mainstreamed to enhance the development of the sector. One of the key objectives of the ICT4AD policy for agriculture is to establish a robust, diversified and commercially based agricultural sector that ensures food security and supply of adequate raw materials to industry, as well as contributes to export earnings. As a result, the Ministry Food and Agriculture has set up two ICT-related departments, namely: ICT Unit and E-Agriculture Resource and Call Centre to drive the integration and mainstreaming of ICT into the modernisation of the sector. Additionally, the private sector, development partners and NGOs have developed several services to support and improve the productivity and performance of actors along the agricultural values chain.

Characteristics of ICT4Ag Services

In total, 24 ICT4Ag services (see Table 17) were identified and clustered in terms of their functions. The major functions were in the areas of provision of extension and market information, market linkages, farm/field data capture and provision for accurate decision-making, financial services, traceability, and others (tractor services, warehouse management, and management of e-subsidy for fertiliser). About 11 of the ICT4Ag services performed only one main service, 9 performed two main functions, while 4 performed three or more functions. As indicated in figure 8, 14 of the ICT4Ag services provided extension and market information, 12 provided services in data capture, while 4 provided traceability services.

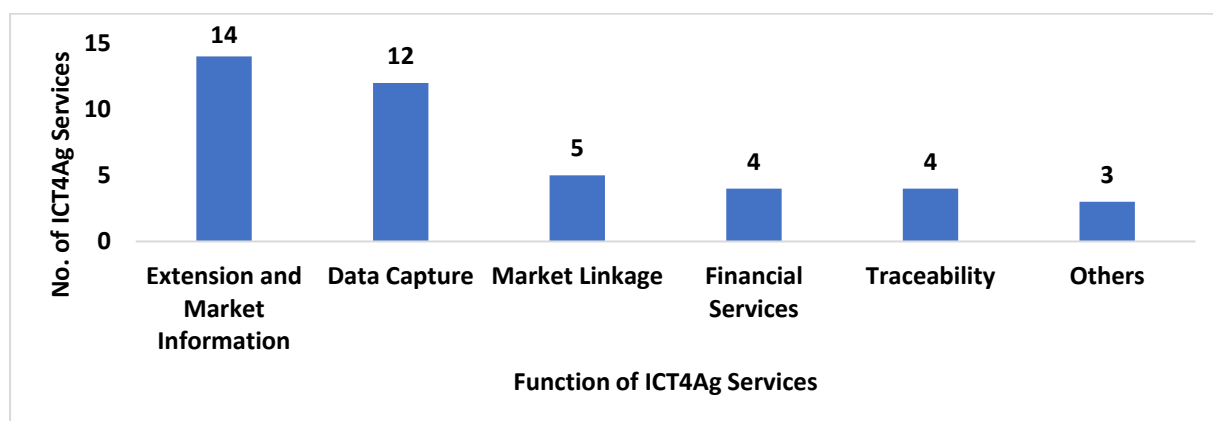


Figure 8 Number of ICT4Ag services per functional cluster

The following section provides some characteristics of ICT4Ag functional clusters that were identified in this study.

Extension and market information

A total of fourteen ICT4Ag services provided extension and market formation to various clients, including farmers, traders and other value chain actors. The ICT4Ag companies in this cluster are:

- Agribusiness Technological Solutions operated by Complete Farmer
- Agricultural Corporate Communications operated by Agrihouse Communications
- Agricultural Intelligence operated by aWhere
- Agricultural Value-added Service (Agri-VAS) operated by Vodafone Farmers' Club
- CocoaLink operated by by Farmerline
- Digital Farm Services operated by Esoko Ghana
- E-Extension Services operated by Ministry of Food and Agriculture- E-Agriculture Programme
- Electronic Agricultural Data Payment Platform (e-ADAPP) operated by 3 Steps Dare Company Limited
- Farm Radio operated by Farm Radio International
- Geospatial Services
- Mfarms Agribusiness Solutions operated by Mfarms
- Mobile Engagement and Information and Communications Technology for Development operated by Viamo
- Multimedia and On-the-grounds Advisors operated by Grammen Foundation
- Video and Multimedia operated by Digital Green

The extension information provided includes good crop and livestock production management practices, field demonstration, market information (such as selling prices), weather forecasts, agricultural tips, and nutrition information. In terms of field data capture and provision of data for accurate decision-making, a total of twelve Services were identified. They are:

- Agricultural Corporate Communications operated by Agrihouse Communications
- Agricultural Information operated by Agric in Ghana media
- Agricultural Intelligence operated Where
- Electronic Agricultural Data Payment Platform (e-ADAPP) operated by 3 Steps Dare Company Limited (3SDCL)
- FarmForce operated by Farmforce AS
- Geomatic Services operated by BenBen
- Geospatial Services operated by SyeComp
- Iska-(Hyper-local weather updates) operated by Ignitia Ghana Limited

- mfarms agribusiness solutions operated by mfarms
- P4P operated by World Food Program
- Research and Development operated by IPA - Innovations for Poverty Action
- Video and multimedia operated by Digital Green

The various functions of ICT4Ag services in this cluster are research and data collection (including personal and biometric data, provision of platforms for agricultural intelligence, building institutional memory for agricultural development projects, mapping, provision of global analytics and predictive insight; platform for tracking or monitoring costs of farming inputs, productivity, volume of sales, financial records and inventory levels of warehouses; provision of optical/radar satellite and UAV/drone imagery and analytics; and weather and yield forecasting). Twelve ICT4Ag services are active in this cluster; these are:

Market linkages

In total, five companies providing ICT4Ag services by creating market linkages for value chain actors were identified. The companies were:

- Agribusiness Technological Solutions operated by Complete Farmer
- Agricultural Corporate Communications operated by Agrihouse Communications
- Agro Trade and Agro Pay Services operated by Agrocenta
- Digital Farm Services operated by Esoko Ghana
- Multimedia and On-the-grounds Advisors operated by Grammen Foundation

The marketing-related functions performed by these ICT4Ag services included linking buyers and sellers over a wider range of channels, for example, through exhibition and trade shows, and creating supply chain platforms that have smallholder farmers on the one end, and large off-takers on the other end so they can trade directly.

Financial services

The functions related to financial services included the provision of financial inclusion platforms, building technologies that connect small-scale farmers to financial services, provision of crowdfunding, and technologies that facilitate and help manage financial transactions. The main ICT4Ag services performing these functions are (1) Agro Trade and Agro Pay Services, operated by Agrocenta, (2) CocoaLink, operated by Farmerline, (3) Crowdfunding for Agribusinesses, operated by Kwidex Company Limited, and (4) FarmForce, operated by Farmforce.

Traceability

Traceability is highly important within the supply chain, as it increases supply chain visibility, improves quality control system and reduces risk. By keeping records of the entire production

and distribution history, suppliers are able to quickly react to any issue that arise. In this study, four ICT4Ag services were involved in the provision of traceability functions. The companies were (1) CocoaLink, operated by by Farmerline, (2) FarmForce, (3) mfarms agribusiness solutions, operated by mfarms, and (4) Track and Trace Technology, operated by Qualitrace. The traceability activities included offering decentralized traceability and certification audit.

Other functions

ICT4Ag services performed other functions, such as tractor services, warehouse management, and management of e-subsidy on fertiliser. Mfarms agribusiness solutions provided services in warehouse management; it provided a platform that allows for monitoring warehouse receipts and inventory. Troto Tractor Limited, which started its operations in 2013, provided tractor services to farmers. The company had built a network of tractor owners from whom farmers obtained services via SMS. The platform enabled the farmer to request, schedule and prepay for tractor services. The tractor operator also got quick requests and payment for tractor services, which usually included ploughing and harrowing. The e-subsidy for fertiliser was an initiative of the Ministry of Food and Agriculture under the E-Agriculture Programme.

Other characteristics of the ICT4Ag Services

Most of the ICT4Ag services identified were established between 2000 and 2017, with the exception of aWhere, which was established in 1991 to provide agriculture intelligence services. The companies, in most cases, targeted farmers and other value chain actors as well as financial and insurance service providers. Some devices used for data gathering and analytics were mobile interface, camera, drones, GPS, tablet (Insyt) sensors, and computer. The most popular media and channels for dissemination were web/mobile application, smartphone application, IVR, SMS, call centre, IVR, USSD, RDD, Canvass, video and virtual workshop and webinar. Most of these ICT-enabled services were supply-driven and led by young entrepreneurs through innovation hubs. These young entrepreneurs took advantage of the niches provided by technology developments in ICTs to churn out services to respond to emerging needs of society. In some cases, the services were donor projects that were piloted in other countries and then extended to Ghana. The involvement of value chain actors in the development of their services was minimal, though they were the intended targets.

All the services were in their advanced deployment stage, except Vodafone Farmers' Club, which was established in 2015 to provide Agricultural value-added services and Kwindex Company Limited, established in 2018 to provide crowdfunding for agribusinesses. Grameen Foundation was piloting a project, which combined the use of digital technology and data, and worked with a rich array of partners, from community and women's groups to global agribusinesses. The World Food Program started the P4P project in 2011 to capture the volumes of products sold and the prices obtained by farmers in different markets, including farm-gate selling and marketing through farmers' organisations.

While information on funding and business model could not be obtained for most of the services, donor funds were mostly from such organisations as The Hersey Company, USAID, World Bank, IDRC, USAID, AGRA, LUX DEV, Rockefeller Foundation, GIZ, Ministry of Food and Agriculture (MOFA), El Salvador's Agricultural Development Bank (ADB), and WFP. Vodafone was operating business-to-business (B2B) model on a per subscriber basis, as well as agricultural value-added service (Agri-VAS) to end customers (B2C). Digital Green also ran the Business to Business (B2B) model, while Farmforce got revenue through client use of the system, in which they paid set up, subscription and professional services fees. Some of the clients used donor funding to support their use of Farmforce services, while the Company also responded to INGO and government request for proposal (RFPs) to support their operations.

Table 17: Providers of ICT4Agriculture Services

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
<p>Agribusiness Technological Solutions</p> <p>Operated by Complete Farmer since 2017</p>	<p>Provides “crowd farming” platform that gives users the opportunity to own and manage on their devices anywhere. Provides solutions from production stage to marketing. The platform has features that include Interactive dashboard, mechanized farming, climate smart agriculture, best management practices, access to markets</p>	<p>Farmers</p> <p>VC: Input provision, production, trade</p>	<p>Device: mobile interface</p> <p>Channel: Smartphone App</p>	<p>Advance deployment- 17,000 acres of farm land, 10 partners, 6 Regions</p>		<p>https://www.completefarmer.com/how-it-works/</p>
<p>Agricultural corporate communications</p>	<p>Initiatives and Projects implementation, research and data</p>	<p>Small-scale farmers (esp. women & youth),</p>	<p>Channel: Webpage, media</p>	<p>Advance deployment</p>		<p>https://www.agrihousefoundation.com/about-us-2/</p>

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
Operated by Agrihouse Communications	collection, conferences and exhibition, advocacy, market linkages, field demos, trade shows.	students, policy makers, governments, institutions, commercial farmers, entrepreneurs. VC: R&D, input provision				
Agricultural information Operated by Agric in Ghana media since 2011	Providing a hub for Agricultural Intelligence, build institutional memory for Agricultural Development Projects in Ghana, and reliable Agricultural News (AgNews)	Farmers VC: Input provision	Device: Camera, drones, media coverage Channel: Media, Workshops	Advance deployment		http://agricinghana.com/

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
<p>Agricultural Intelligence</p> <p>Operated by aWhere since 1991</p>	<p>Farm information, global analytics, predictive insight, Ag-weather, agronomics, Ag-insight</p>	<p>Farmers</p> <p>VC: Input provision</p>	<p>Device: mobile interface</p> <p>Channel: Smartphone App</p>	<p>Advance deployment</p> <p>Cost to users: Services include access to observed weather, forecast weather, historical norm, fields and plantings, agronomic norms. Cost depends on the type of service and the duration.</p> <p>Basic Access Level=</p> <p>= \$50.00</p> <p>Advance Package: =</p>		<p>https://www.awhere.com/</p>

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
				\$150.00 Complete Package: \$750.00		
Agricultural value-added service (Agri-VAS). Operated by Vodafone Farmers' Club since 2015	Offers three agricultural tips a month on the user's primary crop and one nutritional tip as outbond dialled (OBD) calls in a choice of ten local languages. Two- to three-day weather forecasts and four market price SMS are sent monthly in English. Access to expert advice in 14 local languages is free of charge via Esoko	Farmers VC: Input provision	Device: mobile interface Channel: SMS, IVR	Early deployment Cost to Users: GHS2 (0.5 USD)/month). Has been free of charge for members of Vodafone Farmers' club since October 2016 for an extended trial period.	Business-to-business (B2B) model on a per subscriber basis, as well as Agri-VAS to end customers (B2C).	www.gsma.com/mobilefordevelopment/programmes/magri

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
	inbound call centre.					
<p>Agro Trade and Agro Pay Services</p> <p>Operated by Agrocenta since 2015</p>	<p>AgroTrade is a comprehensive supply chain platform that has smallholder farmers on one end and large off-takers on the other end so they can trade directly. This ensures farmers are paid very fair prices for their commodities and also allows them to sell in bulk since the off-takers are typically very large companies ranging from breweries to feed manufacturers.</p>	<p>Smallholder farmers</p> <p>VC: Input provision</p>	<p>Device: mobile interface</p>	<p>Unknown</p>		<p>https://agrocenta.com/about</p>

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
	AgroPay is a financial inclusion platform that provides smallholder farmer who have traded on AgroTrade with a financial ('bank') statement they can use to get access to finance.					
Cocoa Link Operated by by Farmerline since 2014	Provides e-Extension Services e.g. good agricultural practices, weather reports, and market information to farmers: It t provides information, resources, and financial services directly to farmers	Farmers, buying companies and processors. VC: Input provision, production, trade	Device: mobile interface Channel: Voice call, SMS	Advance deployment - About 200,000 farmers across 11 African Countries Cost to Users: Weather forecast= GHS6, GAPS= GHS9, Market prices=	The Hersey Company	0233242141333 Email: team@farmerline.com Albert Bensusan - albert@farmerline.co

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
	<p>through innovative mobile technology. Farmerline has a proprietary software platform called Mergdata that offers decentralized traceability, certification audit, farm mapping, farmer education, and analytics solutions to help organizations that work with farmers achieve their sustainability and food security goals efficiently</p> <p>Farmerline builds technologies to connect rural customers to information, financial services, and supply chains,</p>			GHS11 all over a 6 month period		

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
	with an emphasis on smallholder farmers.					
Crowdfunding for agribusinesses Operated by Kwidex Company Limited since 2018	Allow farmers/agribusinesses source funds from the public, allow everyday people have an alternative source of income by investing in local farmers.	Smallholder farmers, aggregators, markets VC: Input provision, trade	Device: mobile interface Channel: web/mobile application	Early deployment Cost to Users: Free uploads of projects		https://kwidex.com/
Digital Farm Services Operated by Esoko Ghana since 2005	Provided market prices weather forecasts, agronomic advice to smallholder farmers and linking buyers and sellers over a wider range of channels including SMS,	Smallholder farmers, traders, input providers. VC: Input provision, trade, mechanization, financial and	Device: GPS, mobile interface, tablets (Insyt) Channel : SMS, voice SMS, call centre	Advanced deployment, presently in 15 African Countries and still expanding		https://esoko.com

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
	voice SMS and call centre.	insurance companies				
E-Extension services Operated by Ministry of Food and Agriculture- E-Agriculture Programme	Programs established under the e-agriculture resource centre include; e-agriculture portal interactive voice response resource and e-learning centre multi-Directorate call centre resource centre e-field extension service delivery	Farmers, input providers. VC: R&D, input provision, production	Device: mobile interface Channel: webpage, call centre, smartphone app	Advance deployment	West African Agriculture Productivity Programme (WAAPP) with funds from the World Bank	www.e-agriculture.gov.gh/

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
	<p>e-subsidy management for fertiliser.</p> <p>E-Agriculture web portal, interactive Voice Response (IVR) involves use of standard mobile phones to call for free number that can be accessed via MTN toll free number: 30037, the call centre can be accessed via MTN short code 1848 (Toll Free), 0303-967-316, 056-082-3651 and WhatsApp on 027-9090826,</p>					

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
<p>Electronic Agricultural Data Payment Platform (e-ADAPP).</p> <p>Operated by 3 Steps Dare Company Limited (3SDCL) since 2010</p>	<p>Provides access to useful information on the dashboard of the software for use by clients. The e-ADAPP collects comprehensive personal and biometric data of all agri-actors and manages their activities from production to marketing. The solution incorporates a feature that facilitates financial transactions among various actors and the generation of detailed MIS reports for statistical purposes</p>	<p>Farmers, agro-service providers, aggregators, financial services, risk management , agro-processing, retailers and consumers.</p> <p>VC: Input provision, transformation</p>	<p>Device: mobile interface, computer</p> <p>Channel: Smartphone App</p>	<p>Advance deployment</p>		<p>www.e-adapp.com/about.html</p>

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
	on the same platform.					
Farm Radio Operated by Farm Radio International since 2009	1. Radio resources Provision of resources and training to help rural broadcasting stations and create programs that better serve their listeners 2. Radio innovation involves innovation digital solution and new program formats that makes radio more effective and interactive than ever before. 3. Runs radio projects	Smallholder farmers, rural citizens. VC: Input provision	Device: Radio Channel: Media/radio	Advanced deployment, 111 Broadcasting partners, 1995 First broadcasting partner joined, 2010 Country office opened, 2009 First radio project.	IDRC, USAID, AGRA, LUX DEV, ROCK FELLER	0302998872 info@farmradio.org, https://farmradio.org/

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
FarmForce Operated by Farmforce AS since 2012	<ul style="list-style-type: none"> • Conduct paperless surveys effortlessly Traceability And Compliance including Digital capture GLOBAL. GA.P required for production information Organized planting campaigns for cooperatives • Track costs for farming inputs, operators and equipment, harvest • Monitor inventory levels of warehouses • Communicate with field staff and farmers via SMS 15. Manage macro-loans to farmers, which 	Farmers VC: Input provision, production, trade	Device: mobile interface Channel: webpage, smartphone application	Advance deployment Cost to users: Pricing is per farmer, starting at USD5 per farmer	Revenue through client use of the system – set up, subscription and professional services fees. Some clients use donor funding to support their use of Farmforce. Sources donor funds	<u>Laura Johnson Blair,</u> laura.johnson.blair@farmforce.com , www.farmforce.com/

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
	include tracking input-based or cash-based loans					
Geomatic Services Operated by BenBen	Property information searches, thematic parcel data, electronic land solutions	Land and property owners VC: Input provision	Device: GPS, satellite, sensors, camera Channel : webpage, smartphone application	Advance deployment		http://www.benben.com.gh/
Geospatial Services Operated by SyeComp since 2009	Optical/Radar Satellite Imagery and Analytics, UAV/Drone Imagery and Analytics, localized weather forecasting information, farm survey and mapping, mFarm payment, training	Commercial farmers VC: Input provision	Device : GPS, satellite, sensors, camera, drone Channel: Webpage	Advance deployment		https://syecomp.com/

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
	and research services.					
Iska-(Hyper-local weather updates) Operated by Ignitia Ghana Limited since 2015	Hyper-local and accurate weather forecast: Ignitia's flagship product is a 48hour forecast message, delivered daily via SMS, directly to the subscribers' phone. The forecasts also feature monthly and seasonal predictions and detail the likelihood, timing and intensity of the weather.	Smallholder farmers VC: Input provision	Device: GPS Channel: SMS	Advanced deployment stage Cost to Users: Pay-As-You-Go, Farmers make daily payments by using their current phone credit.	GIZ MOFA	http://www.ignitia.se/iska
mfarms agribusiness solutions	Provides tools that allows service providers/banks to track records of all	Commercial and Smallholder farmers,	Device: GPS, mobile interface, camera	Advance deployment		https://www.mfarms.org/ 2333-0243-2546 2332-6438-4557

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
Operated by mfarms since 2010	services rendered to farmers; Collect, validate, process and distribute market information; Field Agents Management; Extension Monitoring; Warehouse Management; Loans Management; Traceability.	traders, input providers, off-takers, organizations . VC: Input provision, trade, production	Channel: SMS, IVR			
Mobile engagement and information and communications technology for development.	Reaching people in the rural areas especially women through SMS and voice call	Farmers (esp. women) VC: Input provision	Device: mobile interface Channel: SMS, call centre, IVR, USDD, RDD, Canvass, Bots	Advance deployment, Over 8 million across 50 plus countries in Africa, Asia and America.	Through donor funding, public and private sector funding.	https://viamo.io/ , Collins Boakye Dankwa (Collins.boakye@viamo.io) 0244131052, Sandra Abrokwa (Sandra.abrokwa@viamo.io , 0509244044)

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
Operated by Viamo, since 2012						
Multimedia and on-the-grounds advisors Operated by Grammen Foundation since 2009	Develops practical solutions for smallholder farmers—whether access to finance, seeds and fertilizer, weather information, technical assistance or markets. The programs combine the use of digital technology and data, and work with a rich array of partners, from community and women’s groups to	Smallholder farmers (esp. women). VC: Input provision, production, trade	Device: Camera, satellite, and mobile phones Channel: Video	Piloting stage. Two hundred advisors work directly with 15,000 farmers, while radio programming and training videos reach more than another 200,000 farmers.	From multinational corporations and government agencies	https://grameenfoundation.org/

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
	global agribusinesses.					
P4P Operated by World Food Program since 2011	The system captures the volumes sold and the prices obtained by farmers in different markets, such as local markets, farm-gate selling and marketing through farmers' organisations		Device: smartphone	Piloting Stage Free cost to users through app	El Salvador's Agricultural Development Bank (ADB) provides credit to farmers to purchase inputs. WFP is working with ADB to develop more appropriate credit products for smallholders that are better adapted to the agricultural production cycle	https://www1.wfp.org/
Research and Development. Operated by IPA - Innovations for	Create high quality evidence. Turn that evidence into better programs	Smallholder farmers, researchers,	Channel: Workshops	Advance deployment		https://www.poverty-action.org/about/what-we-do

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
poverty action since 2002	and policies for the poor.	policy makers. VC: R&D, input provision				
Track and trace technology to authenticate product farm inputs and outputs. Operated by Qualitrace	Qualimart, qualiscan, qualicheck, qualihelp	smallholder farmers, agro input dealers VC: Trade, logistics	Device: mobile interface, camera Channel: smartphone App, webpage, call centre	Advance deployment		http://qualitracegh.com/about/
Tractor Services Operated by Trotro Tractor Limited since 2013	Build a network of "TROTRO" owners that farmers obtain service via SMS. Common platform where the farmer will be able to request, schedule and prepay for tractor services. The	Farmers, input providers. VC: Input provision	Device: mobile interface Channel: SMS	Advance deployment		https://www.trotrotractor.com/

Name of Service and Provider/ Operator	Functions of the Service	Target users and Value chain stage(s)	ICT devices used for data gathering and analytics and ICT channels used for dissemination	Status of deployment & Cost to Users	Funding / revenue generation model	Contact point and URL
	operator on the other hand gets quick requests for tractor (ploughing) services.					
Video and multimedia Operated by Digital Green since 2006	Community video, application software logistic service, online and offline training courseware, data collection and critical analysis and innovation lab	Farmers, implementin g agencies (NGOs), corporates, government and other funders. VC: Logistics	Device: mobile interface, camera, tablet, computer Channel : Video	Advanced deployment stage Cost to Users: Payments for Data, call, subscription	Business to Business (B2B) \$10.8 million organizational budget Expenses: \$7,434,109 Revenue: \$3,854,101 Based on un-audited figures as of March 31, 2017	https://www.digitalgreen.org/

Conclusion

The telecommunication/ICT sector in Ghana has undergone drastic changes due to the enunciation of the policy and legal framework which have facilitated infrastructural development and the deployment of ICT-enabled services. The Ministry of Communications has put in place three policies which liberalised the market and provided a conducive environment for the sector to grow. The legal framework supports the growth of the sector. The policy and legal frameworks have provided confidence to attract private sector investments into the country.

The ICT4AD policy laid a strong emphasis on the utilisation of ICT to modernise agriculture, diversify the sector and develop commercially based agricultural sector to ensure food security, supply of adequate raw materials to industry and contribute to export earnings, among others. The key challenge had been the actual implementation of the tenets of these policies. There is thus the need for Ghana to take advantage of the opportunities offered by the ICT revolution.

The private sector is the key actor in the ICT market, while the government plays a complementary role. Ghana is among the most liberalised ICT markets in Africa. Until recently, the NCA had licenced six mobile telephone operators to provide both voice and data services. MTN is the market leader in voice and data communication, with 49.0% market share in voice, 59.74% share in 2G/3G data services, and almost 93.0%t share in 4G market.

In terms of infrastructure leveraging on the use of ICT4Ag, Ghana has licenced three infrastructural companies to manage and deploy masts/towers to support voice and data services. Also, it has relatively good terrestrial fibre networks which provide high speed data in the country. With the exception of the government fibre network, most of the fibre networks of the mobile telephone companies are located in the southern part of the country where there are strong commercial activities.

Further, Ghana has a landing port for five International submarine fibre cables, and this linked with the terrestrial fibre networks, providing the critical infrastructure for ICT-enabled service development and deployment in the country.

The study identified several private and public-funded innovation spaces, which, if well developed and coordinated, will contribute to the development of ICT-enabled services (including ICT4Ag). About 25 innovative hubs with enormous contributions to the agricultural sector were identified. The ICT-enabled services were supply-driven and not regulated. Therefore, the appropriateness and quality of their contents could not be challenged by any regulatory authority, unless these bothered on criminality, a situation which made farmers highly vulnerable.

Most of the providers of ICT-enabled services, including ICT4Ag, were in their formative stages of development and had no capital base to access the incentive packages put in place for

companies registered with GIPC and Ghana Stock Exchange. Therefore, it is important that innovative ways are found to support companies providing ICT4Ag services in the country. It is hoped that NEIP would provide avenue for financial support for these companies. Further, CST may also negatively affect the utilisation of ICT4Ag services, since the 6.0% tax on electronic communications would increase the cost of accessing these services by farmers.

Digital literacy and affordability were identified as critical last mile issues which need to be addressed. A situation where market forces are the main drivers of pricing of ICT services, especially data-based services, is neither good for business nor for society. Further, building digital literacy, especially among the rural communities, is essential. Already, ICT training has been included in the educational curriculum; this should be extended to those outside the formal education system.

From the discussions so far, it can be concluded that Ghana has developed the requisite ICT industry which can support all ICT-enabled services. The policy and regulatory regimes are favourable to local and foreign investments. It is also evident that a number of ICT4Ag services are in operation in the country to support agriculture and agribusiness development. What is required is an incentive system which these companies can utilise to improve service delivery.

Section Two

Potential of ICT-enabled Services for Improving the Functioning of Agricultural Markets: Case Studies

Introduction

Digital agriculture may refer to tools that digitally collect, store, analyse and share electronic data and/or information along the agricultural value chain. The technology plays a key role in the optimization of food systems. Effective interventions in agriculture are essential for achieving and sustaining economic and social stability. The use of ICTs can be one major intervention in reducing consumer prices, supporting farmers to increase productivity and contributing to more efficient and sustainable agriculture. The expectations for digitalization of agriculture are high because of its enormous potential to address Sustainable Development Goals 1 and 2.

There are many ICT service providers that can enhance the processes in the agricultural value chain. Their services include the development of software for supply chain (such as financial management, mobile applications for farm management, applications for agricultural land use optimization, and precision agriculture applications).

In order to fully realise the solutions that ICT provides to the agriculture value chain, it is important that direct human contacts are built into the operationalisation of agricultural technologies to ensure that end-users have a better appreciation of the solution. Legwork or direct contact with farmers is also important to overcoming barriers to farm inputs and other farming logistics due to remoteness of credit facilities and input services, poor road network, limited internet access and language differentials. To understand how these challenges are handled, this case study was conducted to assess three (3) ICT4Agricultural service providers that combined digital technologies and a network of field agents to deliver information and resources to empower smallholder farmers for increased productivity and enhanced bargaining power in Ghana.

Case One: Farmerline Enterprise

Farmerline was established in 2013 as a social enterprise with a mission to transform smallholder farmers into successful entrepreneurs by increasing their access to information, inputs and resources for increased productivity. It operates a distribution model that combines technology and a network of field agents to deliver information and resources to smallholder farmers in rural areas.

ICT4Ag services have the potential to improve input, output and financial market functioning in Ghana. Farmerline was established in response to challenges in the following areas:

- The absence of quick and cost-effective service for transforming smallholder agriculture into an entrepreneurial hub. This was reflected in the limited access to information, inputs and resources for smallholder farmers to help increase productivity.
- Absence of farmer database that supports the development agenda of government in decision-making.

Consequently, Farmerline designed the following services to address these gaps:

- Provision of real time information and education to farmers through mobile phones. Farmers are now able to access weather forecasts, market prices and good agricultural practices in their local languages anywhere and at any time. This is complemented with extension services and in-person training of rural farmers in agriculture, health and education. This contributes significantly to efficient farm operations and input use by farmers. Indirectly, input and output market access is expanded through information sharing.
- Increasing the participation of farmers in global markets through education of farmers on global certification standards. This helps in connecting farmers to global markets, hence increasing their access to output markets.
- Establishment of Mergdata that contain information on cocoa farmers in the Country in support of development of the sector. The mapping of fields, area determination, and location of farmers, among others, has enabled farmers to access inputs, outputs and financial service supports. Through this technological solution, cocoa farmers are better organised with data available to support investment decisions in the sector. Access to inputs and output markets and financial services is enabled by this database.
- Increasing farmers' access to local markets through mobile phones. Farmers are now able to order high quality inputs, irrigation equipment and other farm tools on their mobile phones and get them delivered on time. This has helped in building credit history for farmers to access advanced financial services in the future.

Farmerline has a proprietary software platform called *Mergdata* that offers decentralized traceability, certification audit, farm mapping, farmer education, and analytics solutions to help organizations that work with farmers achieve their sustainability and food security goals efficiently. The mergdata is a cloud-based surveying and data management tool. The combination of Android application and web service provides instant analysis of data collected in the field and allows broadcasting of voice and text messages to thousands of farmers' phones at a time.

Farmerline's technology has collected insights from over 200,000 farmers across 11 countries, mapped over 700,000 acres of land, and farmers have spent over 300,000 minutes learning best practices on the platform. The company has contributed to increasing farm yields through the provision of quality and affordable inputs to their doorsteps. Customers are also

provided with real-time mobile farming tips, location-specific weather information and market prices in local languages. In 2018, the company was adjudged by Fast Company as Africa's second most innovative company.

Source of Fund

Farmerline is one of 17 thriving agribusinesses to benefit from the African Development Bank's \$23 million grant under the Agriculture Fast Track Fund. As a recipient of this grant, Farmerline's Farmer Services operation has been recognised as one of the most impactful agricultural projects on the continent. The company has used its part of the grant to research more innovative solutions for smallholder farmers. The two key modules that Farmerline operates are Customer Registration and Identification Module and a Digital Finance Module.

Customer Identification and Registration

This module provides proof of farmers (digital identification and demographic profile) and empowers them to access basic services. In order to provide services that deliver on each farmer's needs, field agents put together a digital profile of the farmer, containing their basic information, farming assets and activities. This digital profile helps identify the farmer, enables the farmer to benefit from Farmerline's services and, most importantly, helps track every transaction between Farmerline and the farmer. This digital identity gradually grows to become an economic identity that captures the farmer's transactional history and assets, positioning them to benefit from credit and insurance facilities. Farmers also learn best practices and are able to access vital information using mergdata.

The information gathered through field agents enables Farmerline to learn about the unique needs of each farmer as well as shape service delivery to the profiled farmers. Farmers receive information that is aligned with the type of crop they grow and the season. Good agricultural practices and market prices are examples of such tailored messages disseminated to the farmers. The legwork has also ensured that weather monitors are installed at key points to detect and deliver weather forecasts for specific communities. All this information is delivered as a voice message in the native language of the farmer.

Making inputs available to farmers in rural communities means delivering affordable and quality products at the right time throughout the season. Farmerline's technology allows farmers to place orders for inputs via a USSD platform on their mobile phones. Additionally, Farmerline's well-distributed field agents assist farmers to place orders for inputs. The order is detected and approved; then such ordered farm inputs are delivered through the agent network to the farmer at a price below the market value. By combining technology with legwork, Farmerline is able to gather on-the-ground data that enable it to understand the unique needs of the farmers. The services that are offered to farmers in return enable them to increase their income while reducing cost.

Digital Finance Module

This module integrates mobile finance solutions into the agricultural supply chain. It is currently being piloted in Ghana, after which it will be available in other countries.

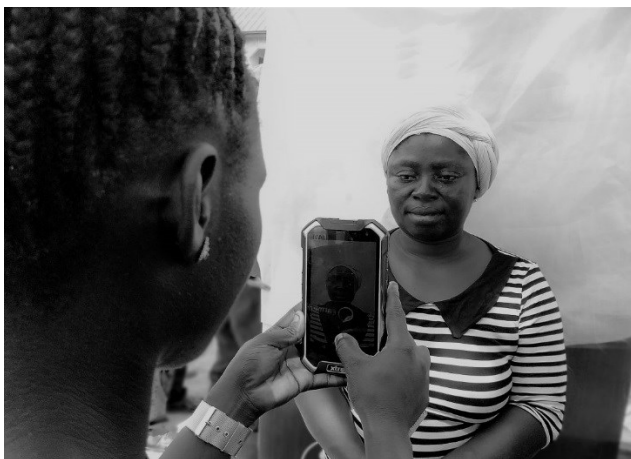
Achievements

Through partnerships with Mobile Network Providers (MNOs), input dealers, agribusinesses, crop-certification bodies, and government entities, Farmerline was able to build digital information on smallholder farmers to supplement their existing financial data. Farmerline has developed a number of digital solutions that provide farmer identification as well as, flexible and innovative means of documenting all farm-related transactions.

To a large extent, Farmerline has been successful in addressing the identified challenges. The merged data base of farmers is now in place for the cocoa subsector, covering 12 districts. Efforts are underway to expand this to many more districts engaged in cocoa production in the country. Through the database, farmers are able to access inputs and financial services.

Digital Profiling

Farmers can secure a digital profile which captures their personal details, such as image, name, contact information and age. The profile also includes asset details like farm size and location. This information is saved onto a digitized identification card which is used during all transactional activities, such as input buying and hiring of tools. All inputs purchase from Farmerline are captured onto the digital ID cards by Farmerline. The card digitally saves all transactions of the farmer for future records.



Digital Records of Assets

Farmlands are key assets that can be used in assessing a farmer's creditworthiness. Farmerline's merged data platform allows for auto and manual mapping of farmlands of varying sizes. The GPS-enabled tool digitally captures the location, boundaries and size of a farmer's

primary asset. These are vital information for assessing the creditworthiness of a farmer who is seeking a loan.



Digital Finance

Farmerline's Farmer Services' digital solutions include digital payments through mobile money platforms. The digital platform enables mobile money payments, which are captured and recorded onto Farmer's digital profiles for recordkeeping. All inputs that are bought can be paid for with mobile money. Soft loans and credits from Farmerline are repaid through mobile money. Mobile finance allows farmers to also receive payments, credits and layaway money for farm inputs. All payments and purchases with Farmerline are also captured and stored on the farmer's digital profile, adding to the transactional history of the farmer.



The combined effect of these solutions is that farmers are given an economic identity backed with well-documented economic activities that can enable them to easily access financial

services. Farmerline’s technology and enabling partnerships ensure that all transactional records of farmers are available on a single platform. The digital nature of the information gathered over time can easily be made available to formal institutions which operate digitally, providing them with insights into a farmer’s economic history and behaviour. Farmerline’s digital solutions are focused on ensuring financial inclusion of farmers, which has a direct impact on crop yield.



Success Stories

Through support from Hershey Company, a US-based candy company and one of the largest chocolate producers in the world, Farmerline has developed the CocoaLink application for Android, using the Mergadata platform. CocoaLink is an information application which leverages SMS and voice messages to exchange information with cocoa farmers. Through gamified and interactive contents in a variety of digital media, such as video, pictures, interactive quizzes, and chatbots, CocoaLink aims to inspire, train, and incentivize the next generation of Ghanaian cocoa farmers.

The target audience of CocoaLink comprises youth aged 18–35 years. Farmerline also engages the youth through churches, universities, and agriculture courses, predominantly in the Ashanti region of Ghana. One of Farmerline’s outreach strategies is their Farmer Field Days, conducted in partnership with university’s agricultural programmes. Farmerline takes students to the field, exposing them to cocoa farming and helping them to learn about the CocoaLink application, and harnessing the power of in-person communication and mentorship. Farmerline has also elected university campus ambassadors to support marketing and feedback collection from young users of the application. The platform has built a community of over 2000 young users in just about a year of being launched. Additionally, Cocoilink serves as a unique avenue for young people in Ghana to learn about cocoa farming and see first-hand how involvement in agriculture can be a profitable and respectable career.

Farmerline is collaborating with Touton, a French trading company that delivers responsibly-sourced cocoa, coffee, vanilla and natural ingredients to create custom mapping and data visualization software on the Farmerline's Mergdata platform. Through the platform, Touton can display an outline of each cocoa farm on a map of Ghana which links to the Mergdata's built-in surveying and data management services, known as *tracing the source*. Furthermore, in partnership with the Ministry of Food and Agriculture (MoFA) of Ghana, Farmerline is improving agricultural productivity, incomes of farmers, and employment opportunities while also establishing effective industry linkage and stimulating development.

Lessons Learned and Scalability

Farmerline has demonstrated that ICT is one of the highly effective tools in engaging youth in agriculture, especially that cocoa farming can be profitable and exciting. By the implementation of Farmer Field Days, Farmerline has also identified the need to specifically target and encourage female participation, as over 80% of the field day attendees have been male. For that reason, Farmerline has been talking to more female students when it attends career fairs at local universities.

Case Two: Qualitrace Company

Qualitrace is an ICT-enabled service provider established in November 2016 but began full operations in 2018. It was built on the concept of traceability of food from the table to the farm gates. Thus, a device or system to trace a particular food back to its origin or source became necessary when there were increased risks associated with consuming foods and there was no link between such foods and their origins.

The potential for ICT4Ag services to improve the functioning of input, output and financial markets is high in Ghana. However, the work of Qualitrace currently focuses on input and output markets and does not cover financial services at this stage. The observed market failures which Qualitrace seeks to address include:

- Growing concerns over food safety issues and the risk posed to consumers. Thus, farmers and consumers find it challenging to identify genuine farm inputs and quality food produce in markets. This is attributed to the poor traceability systems in the agricultural sector.
- Sale of fake and substandard farm inputs (agrochemicals) which threatens both the quality and safety of agricultural produce, as well as health of direct users. Contaminated produce often makes its way into the Ghanaian market, where consumers struggle to verify the genuineness and source of these products.
- Ban on exports of crops treated with counterfeit pesticides, which lead to economic losses for government, exporters and the environment.

Qualitrace focuses on ensuring that farmers and consumers can independently verify the wholesomeness and origin of a produce before purchase, thereby minimizing risks of food

hazards. Qualitrace therefore developed a system to check and ensure quality in food/fruits/vegetables that are produced for the market to guarantee consumers' safety. It also works closely with farmers who are the originators or producers of all foods consumed by both humans and animals in addressing these challenges.

Qualitrace's operational business model employs a platform that connects farmers to verifiable agro-inputs. In addition, revenue mobilization is generated via the sale of Qualistraps, which are the verification tags or scratch panels embossed on agro-inputs. To a large extent, Qualitrace has put in place systems and services that help address these failures, as reflected in what they do and the kind of services offered by the organization, such as:

- Work to protect brand quality and fight against fake or low standard products in markets. Their Field Agents assist farmers to place orders for agro-inputs to reduce the chances of buying fake agro-inputs on the open market (digital agricultural input market platform).
- Promote genuine products on the market through incentive activities such as scratch and win promotions.
- Educate farmers and retailers on anti-counterfeiting solutions. They empower farmers to be able to verify the authenticity of the agro-input purchased. This also helps manufacturers and importers to save money while fighting counterfeiting.
- Clamp down on fake agrochemicals and other products in the market.
- Provide simple verification system that works across all networks and is user friendly to farmers and consumers. Through a mobile application (Qualiscan), farmers are able to identify pest and disease infestation on crops and recommend the best quality agro-inputs. It also assists farmers on practical ways of applying inputs for maximum yields.

These services therefore contribute to expanding farmers' and other value chain actors' access to input and output markets while improving their health status.

Source of Funds

Revenue is generated from commissions made from linking agro-input dealers to the farmers. Donor support and grants also form part of the revenue pool for the operations of Qualitrace. Qualitrace has enjoyed \$50,000.00 seed grant from the Kosmos Innovation Centre. It has also benefited from a \$5000 grant from the Tony Elumelu Foundation and a \$1000 prize money after taking part in the National Board for Small-Scale Enterprises (NBSSI) competition in Ghana. Qualitrace has estimated an amount of \$100,000 in funding requirements to scale up its operations in the coming years. Forty percent (40%) of this fund is expected to cater for marketing, 30% for product improvement and the remaining 30% for human resource development.

Solution/Application

In the quest to employ a traceability system to counter the proliferation of fake agro inputs, Qualitrace has developed a USSD platform for the farmers. The USSD platform works by the farmer dialing *447* and following a combination of numbers obtained from scratching a scratch panel on any agro-input purchased by adding # and pressing a send button. The farmer receives a notification indicating the authenticity or substandard nature of the input thereby putting the farmer in a position to make informed decisions. The USSD platform works on all telecommunication networks and comes at no cost to the farmer.

In the event of pest and disease evasion on crops, Qualitrace has developed an artificial intelligence application that is able to identify pests. This function is compatible with smartphones and works by the farmer using the camera of his phone to take a picture of the infected crop and it is immediately diagnosed with recommended treatment on the phone. This application is however, targeted at educated farmers as well as extension officers to build their knowledge on pest and disease control. The scope of this application is to establish a linkage between the farmer and the agro-input dealer. The diagnosis and recommendation of treatment are complemented by the application suggesting certified agro inputs shops to purchase from.

Key Collaborators

Farmers and agro-input dealers make up the main clients of Qualitrace. Currently, Qualitrace has over 7,000 farmers in Ghana. The farmers are located in the Ejura District in the Ashanti Region, Techiman area comprising Nkoranza, Atebubu in the Bono region, Suhum and Sogakope. These farmers are commonly engaged by Qualitrace through farmer-based organizations or out-growers' platforms, relying on personal contact, workshops or face-to-face interactions.

Agro-input dealers are key and play a major role in the technology that Qualitrace delivers to farmers; hence, Qualitrace, in partnership with Crop Life, has a total number of 18 agro-inputs dealers. However, only three of these agro-input dealers, namely, RMG Ghana, Dizengoff Ghana, Rainbow Chem have accepted to adopt Qualitrace's technology on some specific inputs (seeds and fertilizers). This is to test the technology to ascertain its feasibility so as to roll in other inputs cumulatively. Depending on the arrangement that is reached with the various agro input dealers, the cost of the input may be increased by a few Ghana pesewas to cater for the embossment of the scratch panel where the farmers will scratch and text the digits to the USSD code.

Qualitrace acknowledges the fact that in order to make the technology very useful, there is the need to collaborate with the ministries and other organizations to secure a regulatory backing. To this effect, there is collaboration among organizations such as the Ministries, Crop

Life, PPRSD, Environmental Protection Authority (EPA), Kosmos Energy and other important organizations in Ghana.

Achievements

Besides over 7,000 farmers currently enrolled on its platform, Qualitrace is minimizing the risks of consuming chemically contaminated foods in Ghana through the recommendations of appropriate agro-inputs to farmers. The benefit of this service is also translating into reduction in the cost of agro-inputs. Another impact of the services rendered by Qualitrace is employment opportunities, whereby community agents are recruited to liaise with farmers and input suppliers in several communities in Ghana. Community agents sell Qualitrace solutions to farmers by educating them on the benefits of traceability of agro-inputs. The USSD platform is also used to gather useful data from farmers and input dealers, such as contact, location, and type of inputs sourced/in stock.

The scale of operations of Qualitrace is currently low and falls far below planned targets. Nonetheless, both farmers and consumers are becoming more aware of the importance of traceability of inputs and produce in the markets. More partnerships and resources are needed to effectively scale up the proven technological solutions offered.







Challenges

A limited number of input dealers are subscribing to Qualitrace solutions due to increased competition among agro-input suppliers. There is also the challenge of low rate of technology adoption. In addition, internet connectivity in several communities is a major challenge to the adoption of such technologies.

Lessons Learnt

Qualitrace company seeks to strengthen partnership and collaborations with government agencies, particularly agencies that regulate agro inputs activities in the country. The essence of this collaboration is to enable Qualitrace partner with government through its regulatory agencies to ensure effective monitoring and use of agro inputs with leveraging on its technology.

Qualitrace in Summary

<p>Company Name : QualiTrace Limited</p> <p>Problem</p> <ul style="list-style-type: none"> Farmers are unable to combat pests and diseases attack due to extreme proliferation of substandard and fake inputs. According to CropLife 2016 annual report 40 to 80 of agrochemicals is fake. <p>Solution</p> <ul style="list-style-type: none"> A technological platform that provides verification solutions as well as accessibility to quality, genuine and traceable agro- inputs to farmers to ensure high yields and increase in livelihood. <p>Product/Business Model</p> <ul style="list-style-type: none"> Platform to connect farmers to verifiable agro- inputs. Monetization through sale of QualiStrip(verification tags) Commission on inputs linkages. <p>Competition</p> <ul style="list-style-type: none"> mPedigree, <u>Esoko</u>, YAGRO (Not in Africa); and Source Trace (the verification feature makes it unique and gathers data). 	<p style="text-align: right;"></p> <p>Marketing/Growth Plan</p> <ul style="list-style-type: none"> Reach out to farmer based organizations and out-grower platforms, leveraging on personal contacts, to close at least four more partnership in 2019. Reach farmers through related conferences, fairs and face to face interactions word-of-mouth. In 2020, <p>Management Team</p> <ul style="list-style-type: none"> CEO – Kenneth Nelson – BSc <u>Agribusiness</u> and Finance (KNUST) CPO – Padiki Bukari – BSc Nutrition and Food Science (UG) CTO – Divine Puplampu -BA Computer Science (UG) <p>Accomplishments to Date</p> <ul style="list-style-type: none"> Partnership with CropLife Ghana Provided verification tags for over 140 000 units of products \$50,000 in seed grants from KIC. \$5,000 in grants from Tony <u>Elumelu</u> Foundation \$1,000 being competition award from NBSSI Innovation and Impactful Award 2018 in support of SDG. <p>Funding Requirements</p> <ul style="list-style-type: none"> Total of \$100,000 <ul style="list-style-type: none"> 40% marketing; 30% product (IT/R&D); 30% HR (junior staff)
<p>Company Name QualiTrace Limited</p> <p style="text-align: right;"></p> <div style="text-align: center;">  </div> <p>QualiTrace develops and launches the first USSD verification label</p> <div style="text-align: center;">  </div> <p>QualiTrace Wins 2 Awards at African Youths SDGs Summit 2018</p>	<div style="text-align: center;">  </div> <p>Team QualiTrace featured on several media platforms</p> <div style="text-align: center;">  </div> <p>QualiTrace to launch a new technology for extension officers in Q4</p>

Case Three: Mobile Farms

Mobile farms (Mfarms) was introduced to Ghana in 2011 by Image-Ad, a privately-owned African software development company. It was set up in view of the following failures in the agriculture sector:

- Inefficient government extension system in delivering timely information to farmers
- Poor and ineffective market linkages that facilitates commodity exchange.
- Poor inventory management by agro-businesses, and
- Poor information delivery among actors in the agri-business sector
- Poor linkage of farmers and other value chain actors

Mfarms services connect farmers and aggregators to a ready market; link farmers to agro-input dealers for timely supplies. This helps the agro-input dealers to achieve the desired quantities to stock at various locations.

Mfarms provides mobile-enabling technology solutions, including mobile software development, web application development, consulting and training to farmers. The Mfarms portfolio is an innovative user-friendly mobile and web-based system for managing and communicating within the agricultural value chain. The app was launched to improve operational efficiency and link farmers within the ecosystem. The app provides an aggregation of nine modules on a common platform to deliver various solutions. The Alliance for a Green Revolution in Africa (AGRA) provided grant to Image Ad to scale its services, for Mfarms to be extended to farmers across Africa. Currently, the app is being used in about 19 African countries.

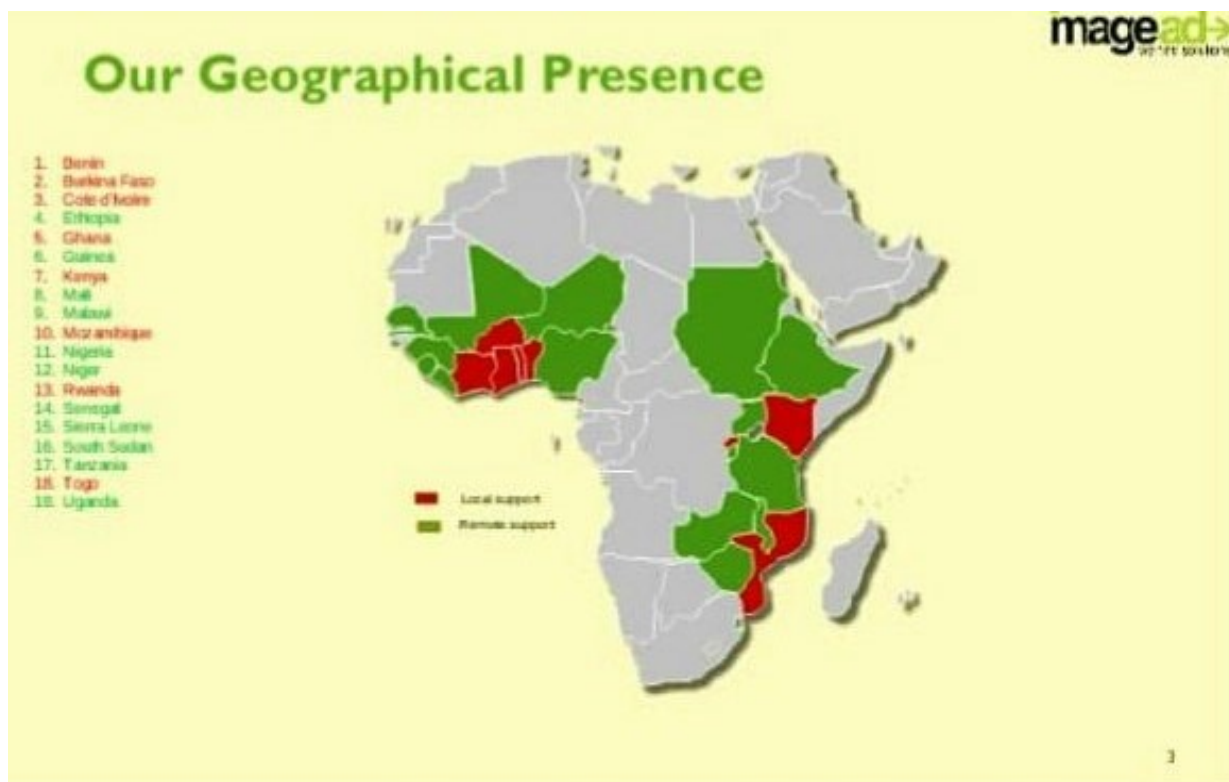


Figure 9 Countries where Mfarm operates

Target Clients

Farmers and input suppliers are the main clientele of Mfarms. Data are directly collected from smallholder farmers using their own mobile phones or Mfarms' modules to record data provided by farmers into a database. The data is used to generate farmer profiles that can be refined over time and made accessible to multiple service providers, such as financial service providers, input suppliers, and agro-processors for better services and financial transactions. Generally, input suppliers are more prescriptive if they have data available on soil and crop health. In addition, agro-processors use farmer data to estimate upcoming harvest volumes and manage traceability of agricultural products. Financial service providers can also use the farmer database to access crop outputs and financial risks. All data collected from farmers using mobile tools are made available on Mfarms' platform are accessible to all value chain actors.

Mfarms utilizes nine digital tools to integrate five areas of the agricultural value chain (planning, inputs, on-farm production, post-harvest: storage, processing, transport; and access to market), as shown in Table 18.

Table 18: Mfarm services in agriculture on digitizing the value chain

CATEGORY	DIGITAL TOOLS	KEY FEATURES
Planning	Actor	Manage Actors' Biodata Track Services Rendered by Actors Track Commodity by various Actors Track Association and Groups by various Actors Track and Manage Actors Benefits Track and Manage Shops and Farms by various Actors
On-Farm Production	Communication Hub	Send SMS and Voice broadcast to actors Conduct SMS and voice surveys in any language and receive response directly on mFarms platform Track delivery status of messages sent instantly to actors Schedule messages on when it should be delivered
Planning	Crop Production	Track and manage all services rendered to farmers Map farmland size of Farmers with a mobile application Keep records of all produce purchased from Actors
On-Farm Production	Extension Monitoring	Creating of activities to be tracked Track activities Assigning of activities Verify activity completion via picture and GPS
On-Farm Production	Field Agent Management	Manage field agents effectively Allow field agents to manage actors(farmers) Assign task to field agents
Inputs	Loan Management	Manage Loans with Guarantees Input Credit Management Loan Credit Management
Access to Market	Market Information	Track Price data on each Commodity Make Surveys of Commodity Prices Forecast on Trends of Prices
Access to Market	Transactions	Track all sales, orders and purchases of retail and wholesale outlets Geo reference of all outlets with their profiles Traceability for every product Better sales analysis
Storage	Warehouse Management	Track warehouse Stock of Commodities Track inflows and outflows Inventory Accuracy Effective Management Control Track farmers

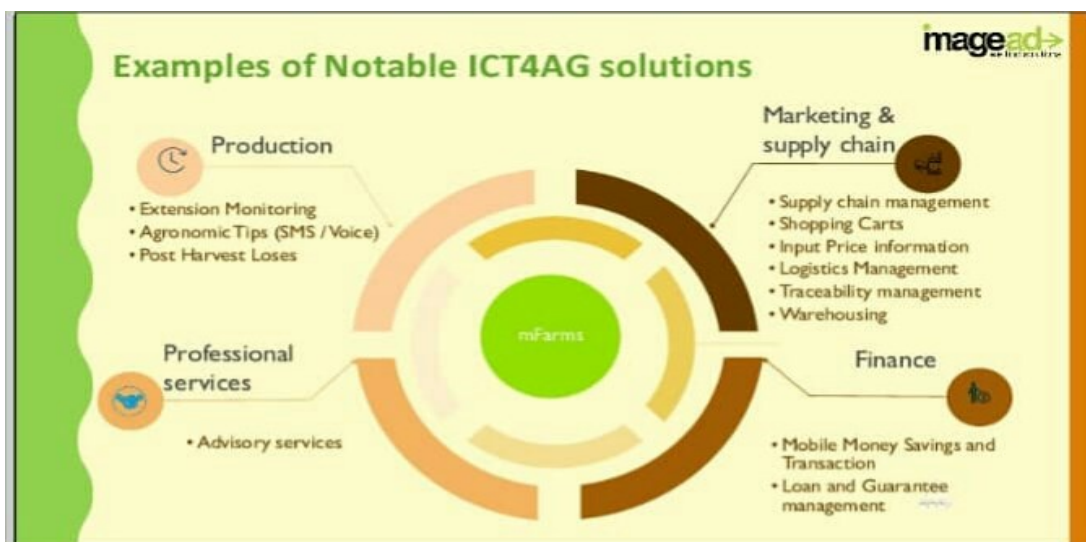


Figure 10. Examples of notable ICT4Ag solutions

To a large extent, mfarms has been successful in addressing the critical areas underpinning its establishment. It has a system that contains the profile of farmers across the country. With this system, Mfarms can link farmers to producers who want to sell specific commodities to aggregators. Data are collected across the regions of Ghana on farmers who want to connect with buyers or output markets, thus, providing output market access for farmers.

Information dissemination in the areas of good agronomic practices, pricing and post-harvest management has greatly complemented the government extension system. Enabling farmers access to input and output markets has been good, though much still needs to be done in this regard. The financial services provided are limited to the loans guaranteed and mobile money services and the fee for service model being operated may not be sustainable due to non-inclusion of farmers. More needs to be done in getting farmers to appreciate and be much willing to pay for the services delivered to them by Mfarms.

Collaborators

Mfarms is a profit-making institution actively involved in the agribusiness space. The enterprise collaborates with UNDP to develop a database application to profile trees planted on cocoa farms in Eastern, Ashanti, and three other regions of Ghana. Mfarms also works with IFDC agro-based in Ghana and in East and Southern Africa. The group provides interventions in the agricultural value chain, including baseline profiles of farmers, credit history transactions, sales patterns, farmer-friendly financial institutions and many others.



Lessons learnt

Mfarms provides one of the best ICT innovations for agribusinesses in Ghana and interacts with many farmers nationwide. In order to raise operational funds, all actors across the agricultural value chain are charged for the services they signed up with Mfarms. Funds are also obtained from projects undertaken with development partners. The main challenge of Mfarms is the reluctance of farmers to pay for services rendered to them. Competition in ICT services for farmers is also a challenge to Mfarms.

Conclusion

Agriculture is the bedrock of many economies in Africa. Therefore, enhancing the contributions of all actors in the agricultural value chain is important. In Ghana, more than 24 ICT4Agricultural service providers are rendering various services to farmers, agriculture input dealers and other value chain actors in various dimensions to increase productivity and the income of smallholder farmers. Notable among the ICT4Ag service providers are Farmerline, Qualitrace, Mfarms, Complete Farmer, Agrocenta, and Esoko Ghana.

Farmerline has a proprietary software platform called *Mergdata* that offers decentralized traceability, certification audit, farm mapping, farmer education, and analytics solutions to help organizations that work with farmers achieve sustainability and food security goals efficiently. Mergdata is a cloud-based communication, surveying and data management tool. This module provides proof of farmers (digital identification, demographic profile) and empowers them to access basic services. In order to provide services that deliver on each farmer's needs, a digital database is developed to identify farmers and enables them to benefit from Farmerline's services. Farmerline's Farmer Services digital solutions include digital payments through mobile money platforms.

Qualitrace, an agri-tech enterprise plays an essential role in the value chain with the services it renders particularly to the end-users. The enterprise is built on the concept of traceability of food from the table to the farm gates. There is a device or system to trace a particular food

back to its source in order to address the risks associated with consuming foods that cannot be readily traced back to their origins. Propagating of a verification and traceability technology that ensures that farmers access quality and high yielding agro-inputs and chemical-free produce is a remarkable service delivered by Qualitrace. Ultimately, Qualitrace, through its services and products, seeks to achieve Sustainable Development Goals (SDGs) 1, 2, 3 and 12 of no poverty, zero hunger, good health and well-being and responsible consumption and production, respectively.

Using mobile tools, data are directly collected from smallholder farmers using their own mobile phones or Mfarms modules to generate a database of farmers. The database is refined over time and accessible by multiple service providers, such as financial service providers, input suppliers and agro-processors, so as to use farmers' history for better services and financial transactions. Mfarms provides one of the best ICT innovations for agribusinesses in Ghana.

All these ICT4Ag companies are rendering relevant services to the agricultural sector and, therefore, must be supported to maintain, improve and expand their services. Qualitrace, for example, may need to explore the development of an application that will also provide guidance to farmers on the safe and appropriate usage of agro-chemicals to minimise the level of chemical residue in foods, which is currently a major food safety concern. There is also the need to assist these companies protect their intellectual properties through the acquisition of the appropriate patents.

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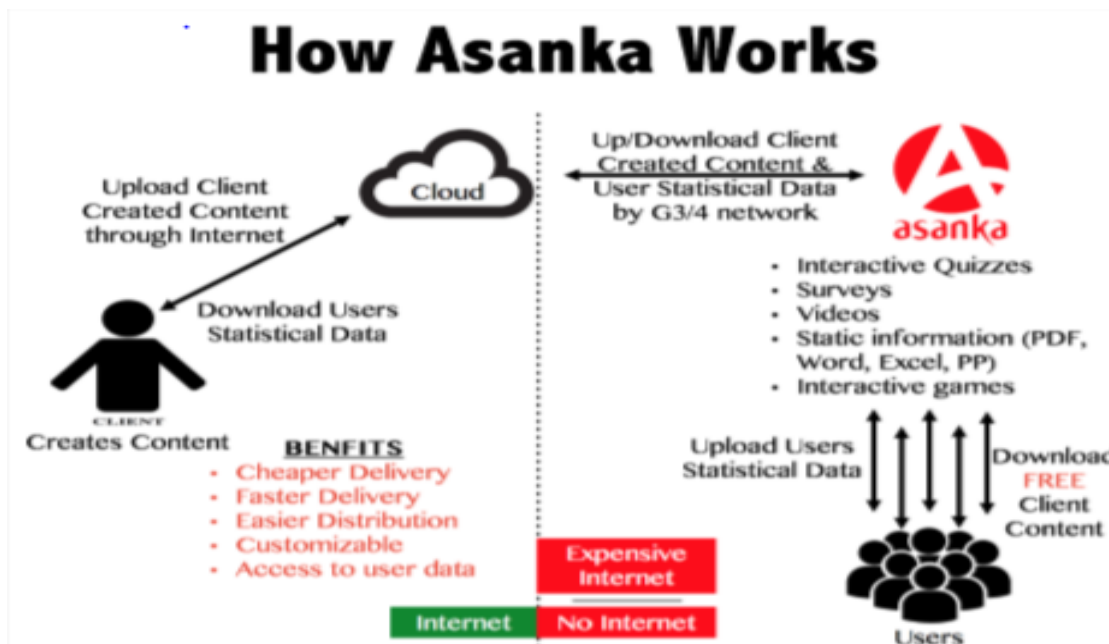
Appendices

Appendix 1: Plan International Ghana

Plan international Ghana has implemented Community-based ICT programmes targeted at improving education. Since 2017, Plan has implemented the ASANKA project in five (5) communities (Boli, Sing, Busa, Baleufili, and Nyoli) in the Upper West Region in two districts (Wa Municipal and Wa West Districts) with technical support from TECHAiDE.

ASANKA is a free Information Access System that works without the internet but like the internet. It is cheaper, faster, easier to access the content, and can be customised. You can track changes over time with surveys, interactive quizzes and games to see how people improve performance and achieve results. The content of the 1Watt device can be assessed by any enabled Wi-Fi device.

The concept of ASANKA is meant to digitalise teaching and learning content for improved performance, promote internet access in remote areas at low cost, and to make educational materials available in working libraries in remote schools. Free resources in ASANKA includes the GES syllabus for every level, the whole of Wikipedia for schools, and other books and videos pre-installed. These contents cover agriculture as well.



The ASANKA system allows users to upload their own content onto the device or to a cloud account which is later synced to the device via an earth net port. Currently, six (6) different compatible formats can be uploaded: video files; audio files, static documents (word, excel, pdf, PowerPoint etc); interactive quizzes, surveys (as a learning tool); and interactive games. The project offers the following solution:

Browse, videos, audios, pictures, documents and play interactive games using smartphones, tablets, and laptop at low cost.

Good connection in remotest areas.

20 different people can connect to one ASANKA Wi-Fi (1 box) without affecting the speed.

The cost per box is USD150, which is paid by Plan International.

1 terabyte of storage available for sharing your own content; and

Content can be broadcast using projectors, audio speakers etc.

Appendix 2: Literacy Bridge

Literacy Bridge (LB), started in 2007, is an information disseminating organization, relying on the Talking Book technology. The organization has worked on various projects for UNICEF, CARE International, MEDA, AGRA and Winrock International over the years with a vision of a world where life-changing information and technology are available and accessible to all, especially the most vulnerable. Literacy Bridge strive to empower the most underserved and poorest people and communities with accessible and quality information and skills in a way that leads to understanding and behaviour change, improved health, incomes, and quality of life.

The Talking Book Technology

The Talking Book is the world's most affordable audio computer designed specifically for people who cannot read and who live without electricity. The device speaks to the user in

their mother tongue. The Talking Book does not require grid electricity but uses batteries that people are already using in their torches and radios. The Talking Book is powered by a pair of dry cell batteries of 1.5 volts each. A pair of batteries last roughly a week after active group listening. Literacy Bridge utilizes the Talking Book to reach hard-to-reach populations, whose needs are often unmet by traditional public health and agricultural outreach efforts given their geographical remoteness, lack of literacy skills and resources.



How does the Talking Book Program work?

Literacy Bridge Ghana provides you with Talking Books and training on the technology.

Amplio Network provides you with dashboard analytics reports.

You or your partners produce audio content.

The audio content is deployed onto Talking Books through a variety of models such as sharing with established groups, health centres or meeting places, a household-listening rotation, or as an extension tool for community outreach agents.

Listeners can choose the topics that interest them most, play content on demand, and record their own messages and feedback.

The Talking Book's content is updated and its user feedback recordings and usage statistics can be retrieved by simply connecting the Talking Book to an Android smartphone – even in places without electricity or mobile Internet access. The app downloads applicable content ahead of time so it can update a Talking Book without a network. The app also uses GPS to ensure the right language and topics are matched with each Talking Book.

After refreshing the content, the app retrieves the user feedback recordings and usage statistics, which it uploads to the cloud-based dashboard once a mobile data or Wi-Fi network becomes available.

You or your local partners listen to user feedback and categorize each recorded message using our Audio Content Manager. This allows the dashboard to track user feedback categories.

The analytics dashboard shows how communities and groups are engaging with the messaging and to what extent the messaging addresses widespread concerns and/or barriers to social and behaviour change.

Based on the analytics dashboard, Amplio Network provides a written report each quarter with recommendations to improve listening and user feedback.

The insights gained through the dashboard and report allow you to continually improve your programs and content.

Advantages of the Talking Book Technology

Simple and easily to operate the device: - The face has common symbols that are easily identifiable and used to operate the device. The device is thus suited for the illiterate clients

Powered by dry cells: This makes it very suitable for people who have no access to electricity and may live far away from gridlines.

Use of local languages and dialects: – appropriate content and messages are in the users' language, thus facilitating understanding. The device therefore talks to the people in their own language

Device is interactive: – Users can endorse messages, make contributions and ask questions by simply recording their queries or concerns. This is one advantage over radio broadcasts.

Consistency in messaging: – information passed on from person to person by word of mouth has a tendency to lose its consistency. Even experts are unable to repeat their ideas verbatim when moving from one community address to another. The device records and enables experts to put their ideas across in a consistent manner

Listening at your convenience and playback – The device allows listening to messages at the user’s own convenience. Users also have the opportunity to playback messages for understanding and emphasis, an advantage the device has over radio broadcasts.

Self-monitoring: – the device has the ability to collect usage statistics and user feedback. Every individual device once deployed is linked to a dashboard that is able to show whether or not the device is used by the beneficiaries.

The device does not depend on internet services for operation. There is no need to own a mobile phone, buy top up credit or regularly charge the battery.

Facilitates technology transfer: – training of agents on simple repairs and troubleshooting, leads to some level of technology transfer

Achievements made with the Talking Book Technology

As a behavioural change tool, Literacy Bridge partnered with UNICEF in 2014 to scale up the Talking Book program on health and agriculture to 49 communities in the Jirapa District. Farmers have reported increased crop yields after applying the knowledge gained from the Talking Book.

Mothers learnt the importance of sleeping under Long Lasting Insecticide Treated Nets (LLINs) through the Talking Book technology and reported that fewer children are now falling, leaving more time to work. Proper hand washing messages learned from the Talking Book has also reduced the incidence of diarrhoea.

In partnership with the MEDA GROW project which is aimed at improving food security for families in northern Ghana, the Talking Book technology has helped women farmers to increase food availability, accessibility and utilization through strengthening market linkages, increasing diversification in production, and creating awareness of nutrition.

In evaluating the Talking Book technology application in 2014, MEDA reported that every participant they interviewed felt that the Talking Book is a useful tool for learning that has helped them acquire knowledge on soya agronomy, marketing, gender issues, nutrition, and financial services. About 75% of the individuals interviewed reported sharing information learned with family members and friends and said that the Talking Book messages facilitates family cohesion.

In 2017, LBG evaluated the TUDRIDEP/AGRA project which relied on the Talking Book for behaviour change among small holder farmers in the Upper West Region and found that the device had indeed changed their lives positively. Thus, most farmers reported increased adoption of sound agronomic and soil management practices, post-harvest management and storage practices. Farmers were able to increase productivity of Soya from 0.64 to 1.65 tonnes per hectare and Maize from 1.65 to 2.74 tonnes per hectare respectively. Input and output market linkages were also reported strengthened.

In the 2018 survey on the CARE International Pathways project, all respondents (100%) stated that household decisions around the education of children, sale of crops/animals, consumption of farm produce, marriage of daughters, allocation of farm lands, child-bearing issues, and health/nutrition issues were jointly determined by both husband and wife. The Talking Book Technology therefore has a significant change in people's attitudes and perceptions.