Digitalization of Agriculture: How Digital Technology is Transforming Small-Scale Farming in Ghana

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List of Acronyms

AECOM	Architecture, Engineering, Construction, Operations, and Management
CGIAR	Consortium of International Agricultural Research Centers
CIAT	International Centre for Tropical Agriculture
CTA	Technical Centre for Agricultural and Rural Cooperation
DFS	Digital Financial Services
DFS	Digital Farmer Service
DO	District Organizer
FAO	Food and Agriculture Organization
GIS	Geographic Information System
GPS	Global Positioning System
GSMA	Global System for Mobile Communications
ICT	Information and Communication Technology
IFC	International finance corporation
IFPRI	International Food Policy Research Institute
IOT	Internet of Things
LD4D	Livestock Data for Decisions
MDG's	Millennium Development Goals
MOFA	Ministry of Food and Agriculture
NGO'S	Non-Governmental Organizations
PA	Precision Agriculture
RA	Research Assistant
SDG's	Sustainable Development Goals
SLAM	Simultaneous Localization and Mapping
SMS	Short Message Service
UKAID	United Kingdom Aid
USAID	United States Agency for International Development
USSD	Unstructured Supplementary Service Data

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Abstract

This paper examines how digital technology facilitated by digital platform (Esoko) in providing advisory services to farmers through mobile phones, and how Agroecom company obtain data digitally from farmers while engaging them in business affect their production. Mostly, small-scale farmers in cocoa growing areas receive services from platforms. This paper investigates how data is obtained from farmers and used and who benefits from it, the effect of digital technology on the autonomy and indigenous knowledge of farmers and how digital financial services affect small-scale production.

Data was obtained by digital platform (Esoko) through the initiative of the state, they then use the data to provide weather and market information through remote extension services via mobile phone applications to farmers. It found that farmers benefited by using the information to adapt to weather changes and access the market respectively, however, data was obtained in a manner that did sought the consent and ensure the privacy of farmers, because data is used for other business purposes. Also, Agroecom company obtain data for research to ensure good yield of cocoa and to consolidate their businesses with farmers across the value chain through the provision of their products (inputs). I argue that digital platforms and other companies may benefit from data more than small-scale farmers. It also found that the use of digital technology by companies is likely to lead to dependency thus undermining farmers indigenous knowledge which may deny them of some autonomy, however, farmers are trying a create a balance employing both knowledge systems. Also, it found that Digital Financial Services (DFS) has promoted access to some financial tools among farmers and enhanced marketing within the value chain. Moreover, younger and educated farmers are able to access digital technology more than older and uneducated ones. It found that extension agents, farmer associations and the electronic media are also an important source of information to farmers and must not be underestimated. The study identified some obstacles confronted by farmers in accessing digital technology, they included, low technical ability among farmers, high cost of call credit, low digital infrastructure, and internet connectivity.

Relevance to Development Studies

Digitalization of Agriculture is a new trend that is enabled by digital platforms aimed at providing agricultural services to farmers in Ghana. Earlier research on the rise of other kinds of technologies in agriculture especially the green revolution introduced (e.g. new inputs like chemicals, GMO seeds) have tended to lead to a rise in cost of production, destruction of the environment, damage to genetic diversity and creating a system dependency on food from western corporations (Herring, 2015). Although digital technology is believed to be able to bring significant transformation in agriculture (Fielke et al., 2019). It could also run risk of relying on technical expertise rather than tacit knowledge from the farmer (Ingram and Maye, 2020). This could affect the food security situation in the country because traditional farmers rely on their own knowledge. It is widely known that agriculture employs majority of people in the country. The fact that agriculture employs the majority of the population calls for a prudent action by the government to prioritize the opportunity within digital technology to meet the challenges such as climate change, food and nutrition security and youth unemployment by making the right policies and investment.

African countries are seen as new emerging markets and digitalization is seen as a means to reach poor consumers/clients in remote villages previously largely outside the reach of multinationals. The legal frameworks regarding data protection are still weak in these countries, and awareness among the rural population regarding data protection and privacy issues are low, and therefore there is a strong need to protect their data to prevent others from taking undue advantage. There is a need for the government to establish a regulatory framework that will protect data as easy access by foreign companies and government can pose danger for economic and political development. There must be new models of alternative technologies which will be in consonance with people's rights, social and economic justice and democracy with decentralized ownership and control of the core structures of digitalization: software, hardware, and network (Kwet, 2019). Further, since digitalization has the potential of providing new opportunities in the sector, the necessary safeguards must be provided in order to allow small-scale farmers to follow their own path to development and not depend on corporations.

This research could contribute to policy guidelines for the communication industry, government, NGO's, mobile network operators, digital platforms, and private companies. These policy decisions could position institutions well in advance. Finally, there has been little research on digitalization in Ghana especially in social science, therefore, this study will provide information that might help to inform more elaborate future research on digitalization in Ghana.

Keywords

Small-scale Farming, Digital Agriculture, Data, Technology, Mobile Phone applications, Platforms.

Chapter 1 **: Introduction**

In recent years, there has been attempts by companies to introduce digital technology within the agriculture value chain in Ghana seeking to provide digital solutions to farmers (Loukos and Javed, 2018:7). Some studies and reports on digitalization of agriculture have identified some potentials. For example, the Technical Centre for Agricultural and Rural Cooperation (CTA) report on African digitalization claims that data quality and digital solutions could minimise service cost, information delivery to farmers, inputs, and other services across agriculture value chain (Tsan et al., 2019:17). Similarly, digital agriculture is believed largely to provide improvement in productivity, sustainability, and effectiveness along the value chain (Wolfert et al., 2017). Others have cited that digital financial services (DFS) could be another approach to providing greater financial access to small scale farmers in a flexible and suitable manner in rural communities (Caron, 2020). Many governments, mobile phone companies, donors and non-governmental organizations see mobile phones as a tool for economic development (Aker and Mbiti, 2010:220).

While many see digital agriculture as to have the potential of enabling to manage our farmlands and other activities on the farm (Eastwood et al., 2017), studies carried out by others have contrary views on its impact on small scale agriculture. Questions have been raised regarding the social, technical, ethical, and economic impacts it will have on agriculture (Ingram and Maye, 2020:1). Some have identified ethical concerns regarding the use of digital technology (carbonell, 2016; Wolfert et al., 2017; Van der Burg et al., 2019). Others also question the impact on the independence of farmers and its sustainability since much of the technology is being sponsored (Ajena, 2018; Schimpf, 2020). The fast rate of increase in digital platforms across the value chain in Ghana raises many questions. Cargill have been making profiles of cocoa farmers, registering, certifying, and making payments to farmers on a digital scheme since 2013 (Loukos and Javed, 2018:15). This needs much attention due to the potentially far reaching impact it will have on how? small holder farmers will be integrated into the global market system.

The purpose of this paper is to explore the dynamics of digital agriculture provided by some companies obtaining data and providing service through mobile phone applications and how it affects small-scale farmers in the Eastern region of Ghana.

This paper consists of five chapters. The first chapter consist the background of the study, the problem statement, research objectives and questions. Chapter two introduces the concepts on digital agriculture, potentials of digital technology, shortfalls, issues of Data, ownership and use, and digital agriculture as a power relation. Chapter three consist of the theoretical framework and methodological strategies. Chapter four consist of the how digital technology interact with small-scale farmers and the effects that arise from that encounter and chapter five concludes the paper with policy recommendations.

1.1. Contextual Background

The transformation of the peasant economy in Ghana could be traced back to the period of colonization, transformation which occurred through the introduction of commercial agriculture. According to (Kansanga et al., 2018) the agriculture policy during the colonial period in 1874 was cash crop-export based, where focus was on the production of coffee, cocoa, and rubber to the neglect of food crops. Lands were acquired by merchants and elites for commercial purposes from chiefs who were influenced by the British through indirect rule system (Nketiah, 2013:8). This period saw the acquisition of large tracks of lands for the

cultivation of cocoa plantations in commercial quantities. The Colonial state employed various means such as force and enticing structures that involves indirect rule via chiefs aimed at producing commercial crops to support the economies of the metropoles (Yaro, et al., 2017:539).

The expansion of capitalism through colonization created a dependent relationship in which the capitalist metropoles dominated its colonial peripheries in Africa, Asia, and Latin America (Frank, 2009). Frank adds that this dominant relationship continues to take shape even today in regions, countries, and the rural spaces through exchange. In the 1940's to 1970's there was a reconfiguration of capitalist expansion, accumulation, and legitimization through the so called Green Revolution, that shaped farming through state-led modernization, import subtitution (Patel, 2013). This created a system of continuous dependence on Western methods and agenda in farming through the state. Whereas the Green Revolution yielded to increased agricultural production in numerous Asian countries in the mid 1960's through strong Western support, state interventions and investment that promoted small holder intensification, the situation in Africa was marked by much less Western support, through neoliberal agendas aimed at implementing structural adjustment program in the 1980's (Dawson et al., 2016). In Ghana, conditionalities imposed by the programmes on government had adverse impacts on small scale farmers, and the removal of government subsidies on agriculture decreased production (Kraus, 1991). Trade liberalization forced the state to privatize state corporations that supported small-scale farming. For example, the fertilizer manufacturing and distribution company and the state marketing corporation were taken over by foreign companies. Kraus posits that, the introduction of modern technology and agro-inputs by foreign companies introduced a market economy and the integration of the agriculture sector into the global market system. Digital technology that is facilitated by digital platforms to offer services to farmers in Ghana and supported by the state through its digitalization agenda may not be different from the technology introduced by the new Green Revolution.

Some studies have observed that digitalization could be a new form of colonization that is taking shape in the political, economic and social space of the Global South (Kwet, 2019). According to Kwet, most farmers could gradually become dependent on multinational corporations who provide digital services through local platforms, where data obtained from farmers are used to provide products and services. Digitalization of agriculture where small scale rural farmers and their produce are being profiled into the database of multinational corporations as reported by Loukos and Javed (2018), could be a way of incorporating farmers into the global value chain. Kwet observed that there is a domination through the ownership and control of the main structures of the digital ecosystem which include software, hardware, and network connectivity, which creates hegemony within the digital space (Kwet, 2019).

Digitalization in the Global South is centred around how big data is changing the agri-food sector. Technology like Simultaneous Localization and Mapping (SLAM) is a self-learning platform that uses farmers feedback to create apps that automatically generate advice to farmers using simple agronomic models (Meadu, 2019). Livestock Data for Decisions (LD4D) also rely on the data from livestock to carry out research and make interventions in India. Even if these platforms are supported by big players in global research like UKAID, International food policy research institute (IFPRI), International centre for tropical Agriculture (CIAT), the ownership and the benefactors of these data remain a mystery. In Africa, digital services have been growing rapidly. It has been observed that about 400 players in digital services and products operated through-out Africa providing various services, out of which many are concentrated on financial services. Most of these services are concentrated in Kenya, where twenty-two digital financial services providers for agriculture serve as the

headquarters of most firms (Caron, 2020). Incorporating farmers into agribusiness requires using digital sources to build their profiles. These sources are images of farms and crops captured from satellites and drones and mobile surveys can be answered from a mobile phone. However, ensuring data privacy and security of the farmer becomes a problem because the data is not owned by an individual since it is connected to satellite. Despite these concerns, the use of technology in agriculture, has many potentials of turning the sector around. Digital solutions have the capability of strengthening and accelerating agricultural transformation in Africa, it provides farmers with information and insights to new products and services and market linkages and ensures sustainability and inclusiveness (Tsan et al., 2019:17-18). Moreover, mobile applications help in the transfer of technology which can increases agricultural production and marketing, Mobile platforms also bring progress in research data that inform policies to improve the livelihood of small-scale farmers (Trendov, et al., 2019:96).

Over the last few years, Ghana has witnessed an increase in the use of digital application in agriculture enabled by digital platforms and operating among small scale farmers across farming communities in the country. The past years have seen many enterprises that sort to digitize the agricultural value chain by obtaining procurements to farmers and creating a profile of farmers including their farms (Loukos and Javed, 2018:). It is important to note that, Agriculture is one of the most dominant sectors of the economy in Ghana, as the majority of the people who engage in agricultural activities are rural dwellers. The contribution of agriculture to the GDP of the country was 18.9 in 2016 while employing about 70% of rural folks (World Bank, 2018). The agricultural sector is grouped into six sub-sectors namely, livestock, food crops, forestry, poultry, industrial crops, and export crops and dominated by small scale farmers who provide 90% of the food needs of the country (Acheampong, 2019:178). Among the small-scale farmers, females form 52% of the entire population according to (FAO, 2018). Female farmers form a majority in the sector in Ghana involving in all activities in the agriculture supply chain and will be most affected in the introduction of new technologies. Ghana has six ecological zones which include Tropical rainforest, guinea savannah, Sudan savannah, semi deciduous forest, coastal savannah, and transition zone (FAO, 2005). Despite the important contribution agriculture plays in the economy, small scale farmers have insufficient technology to increase production but rely on simple tools for farming which retards their growth. Digital agriculture initiatives are aimed at addressing this technical gap such as access to market, unreliable weather prediction in growing crops and access to inputs among small-scale farmers by deploying various digital tools in the value chain (Panel, 2019).

Apparently, most of these digital platforms also target small scale farmers within the semi deciduous ecological zone. Perhaps, these platforms have affiliations with foreign counterparts as indicated above who are big players in global value chain perspective, which means they do not operate in isolation. They could be linking corporations to these small-scale farmers since platforms also create market linkages as part of their role as seen in Esoko's business models (Esoko, 2020). Global System for Mobile Communication (GSMA) has a framework model used for agricultural last mile digitization for agribusiness in Ghana. These models are being supported by the Bill & Melinda Gates foundation, the Mastercard foundation, and Omidyar Network.

The government has played a vital role in digitization in Ghana. The state is trying to unlock the potentials in agriculture by leveraging on digital technology and putting appropriate policies to ensure 'agripreneurs', small scale farmers, farmers organizations and other players in the agriculture value chain to employ the use of digital technology for efficient operations (Ghanaweb, 2018). The state launched an agenda on digitalization in 2016 aimed at digitizing every sector in the economy, Although this initiative could improve the

agricultural sector: the appropriate digital infrastructure, regulations, and capacity building for small scale farmers are not in place. While the state is instrumental in championing this agenda, there is concern for the right regulatory framework to be put in place for the protection of data and rights of farmers.

1.1.2 Brief background of Esoko Platform

This paper will focus on the case of Esoko platform and farmers in East Akim in the Eastern region of Ghana. Esoko is a company providing digital service to farmers across 20 countries in Africa, it was launched in Ghana in 2008. It started as a software tool which collects and disseminate market prices and later providing weather forecast, crop advisory. In 2012, it established live call centres in multiple languages along with voice recorded content and advanced into platform registration and service delivery partnering with mobile network operators (Esoko, 2020). It also engages in biometric profiling and financial services which focus on leveraging mobile for savings plans for inputs-fertilizer and seeds. In 2018, it became a community tech platform that provide tools for profiling, communication, and service delivery (Esoko, 2020). The 'digital farmer services' provided by Esoko Ghana are an ecosystem that links farming communities to the service. It also provides information on weather, market prices and crop tips, they create market linkage by connecting farmers to buyers, and profiles farmers information on cash transfer and input subsidies, delivering insurance to beneficiaries and enrolling beneficiaries to pension benefits and GIS mapping of farms (Esoko, 2020). Esoko has several organizations that partner with it, some include USAID, Wienco Agriculture, International Finance Corporation (IFC), Vodafone and AECOM. The semi deciduous forest and other ecological zones are particularly important to these platforms because of the favourable nature in Agriculture production.

1.2. Research Problem Statement

Digitalization of agriculture is virtually becoming a household name among many players within the agriculture value chain in Ghana especially among digital platforms, private investors, and some politicians as well. Digital technology through mobile phones is being adopted at a fast rate in Sub Saharan Africa, for example mobile subscriptions have risen from 16 million in 2000 to 376 in 2008 (Aker and Mbiti, 2010:210). Digitalization holds the potential of transforming small scale agriculture positively; the use of mobile phones has provided information to farmers (Aker, 2016). It has also brought financial inclusion among female (Owusu et al., 2018) and young farmers through mobile money, many producers reach out to middlemen through mobile phones as well as receive payments of produce in the form of mobile money (Loukos and Javed, 2018) which eventually could develop a habit of saving among farmers. CTA Africa report on digitalization of agriculture highlight the potential of digital technology solutions in transforming small production by creating traditional business models which will reduce cost of service, information, and inputs, not only that but can also promote sustainability and inclusiveness of women and the young (Trendov et al., 2019:17).

While this sounds very promising for the sector especially among small scale farmers, studies show that some small holder farmers do not have the technical knowledge and capability to operate mobile phones and thus unable to take full advantage to ensure fairness to realize its benefits (Owusu et al., 2017:38). The rate at which the change is occurring without the necessary infrastructure and training to farmers could therefore put farmers on a disadvantage position.

The fact that the Global South is a new emerging market for financial, digital, and business infrastructure need to be taken seriously because innovation firms are building the

infrastructure to secure new markets (Mann, 2017:12). In Ghana, digital platforms make profiles of farmers, mapping, providing them with advisory services and creating market linkages (Esoko, 2020; Loukos and Javed, 2018). These market linkages especially to agricultural input companies could make farmers become dependent on these corporations within the value chain for the products and services. They could also take advantage of the digital terrain to exploit vulnerable farmers who are yet adopting the technology. As observed by others, the adoption of technology has forced small scale farmers to become dependent on inputs manufactured by multinational corporations such as Syngenta and Bayer (Herring, 2015:45). For example, it is widely observed in Ghana that farmers obtain agricultural inputs from input providers every planting season. Although some use locally made manure and compost, they depend very much on imported inputs. Delgado et al., (2019:3) claimed that Information Technology has disrupted industries by creating efficiency for the market through automation and decision-making tools by including people and consumers.

This practice of incorporating small-holder farmers into the global agriculture value chain could lead to dispossession (Thatcher et al., 2016). This is because the small-scale farmer could eventually become dependent on corporations for inputs, funding, and new farming techniques. Subsequently, farmers may lose their power to make decisions regarding production in the long run. This process has been described by Langley and Leyshon as 'platform capitalism' where a business model or ecosystem interconnect to multiple entities and extracting revenues across the chain and having the possibility to 'realize monopoly rents' (Langley and Leyshon, 2016:2). Some questions have also been raised regarding how machinery manufacturers, seed lobbies and chemical input providers are increasingly encouraging and funding the innovation, who has control of the data and access to the technology (Ajena, 2018).

It is important to note that, most funded investment in agriculture affects farmers in terms of their reproduction and growth which may lead to differentiation within the agricultural value chain (Langley and Leyshon, 2016). The reliance of farmers on digital technology provided by corporate bodies is likely to threaten their autonomy since it can create a system of dependency where farmers will continuously rely on platforms for new skills and other means of production.

In Ghana, most of these digital platforms operate in areas which are predominantly cocoa (Loukos and Javed, 2018:18). Cash crops such as cocoa usually occupies a large area which can deny other food crops of cultivation. Similarly, Ghana Rubber Estate Limited (GREL) rubber plantations occupy large hectares which consist of 20,000 hectares on its plantation and 42, 000 out growers' schemes (Loukos and Javed, 2018:17). This has the tendency of not only denying small-scale farmers of land but could worsen the food insecurity situation in the country.

It is worth nothing that many farmers use everyday knowledge acquired on their experience, observations and knowledge inherited from ancestors, others, and agricultural specialists (Schimpf, 2020:10). Schimpf added that Farming in general is a knowledge-based activity, usually associated to specific geographical locations and within individuals and their farms. Also, drawing from the case of 'Farm Hack' it has observed that tacit knowledge of producers can be replaced by digital knowledge (Carolan, 2017:830).

In addition, as indicated by Fraser (2019) data grab is now a battleground over the future of farming. Access to farm data could provide an avenue for financialization which may lead to an increase in land grab. Farmers who obtain credit through digital platforms sometimes use farmlands as collateral and can become indebted during crop failure and risks losing their land which is likely to affect their production. The spread in financial investments has opened new grounds for the accumulation of capital within the agrifood value chain (Clapp and Isakson, 2018:439). While there are varieties of credit within the rural certain in Ghana

providing support to farmers, financial support from corporations in Ghana has the tendency of not only causing the phenomenon of dependency but reducing the power of small holders. According to Yaro et al. (2017:539) international donor organizations have an agenda of changing small-scale farming and linking them with the global value chain. This stems from the fact that most of these farms are literally being financed by foreign companies.

Further, digitalization of agriculture could also generate the issue of power relations between actors in the food system (Bronson and Knezevic, 2016; Carolan, 2017; Carbonell, 2016). Bronson and Knezevic, (2016) stressed that the network of actors involved in digital agriculture could benefit more while burdens shifted to farmers. Providers of digital technology could take advantage of small-scale farmers who are adopting the technology due to the influential power they possess. Farm decisions could be determined by providers of the technology denying the farmer of autonomy.

Considering the performance of new technologies in the past such as the Green Revolution which is generally known to have had opposition due to the adverse impacts on agriculture in sub-Saharan Africa, digital technology may risk following a similar trend. It could threaten small-scale farming which many people in Ghana rely on. It could gradually lead to dependency, loss of indigenous knowledge, dispossession and threaten livelihoods. Hence the need to investigate the new technology.

1.3. Research Objectives and Questions

To understand the dynamics of digital technology among small scale farmers, this research seeks to achieve the following objectives and will try to provide answers to the following questions:

1.3.1. Objectives

a. To explore the effect of digital technology on the autonomy and indigenous knowledge of farmers
b. To investigate how data is obtained and used from small-scale farmers and who benefits from it
c. To understand how digital financial services, affect small scale production

1.3.2. Research Questions

In unraveling the dynamics of digital technology among scale farmers, this paper will try to answer to the following questions:

1.3.3. Main Question

In what ways does digital technology affect production among small-scale farmers?

1.3.4. Sub Questions

a. What is the effect of digital technology on farmers autonomy and indigenous knowledge?
b. How is data obtained and used from small-scale farmers and who are the beneficiaries of such data?
c. How does digital financial services affect small scale production across the value chain?

Chapter 2 **: Digitalization of Agriculture**

2.1. Conceptualizing Digital Agriculture

> "As digitalization transforms agriculture, the implications of cumulative innovation processes are essential to consider in order to mitigate risk and capitalize on opportunities". (Fielke et al., 2019:1)

Agriculture has undergone many changes from the Neolithic period as people keep innovating to improve production. The scientific era has seen yet another revolution in agriculture technology which is digitalization. Digitalization generally entails how digital technology impacts on the society in our every-day life, environmental interactions and its functions in economies (Fielke et al., 2019:1;Yoo, 2010:213) a sociotechnical method of applying digitizing techniques to a larger social and institutional settings (Tilson et al., 2010).

Digitalization of agriculture, however, encompasses the advancement, adoption, and recapitulation of digital technologies in agriculture (Fielke et al., (2019). The term has different names in different contexts, for example 'digital agriculture' in Australia and New Zealand, Smart Farming in the European Union and precision agriculture in United States of America. Digitalization of agriculture is a situation where technologies are integrated like the Internet of Things (IOT), Big Data, sensors, robotics, Artificial Intelligence, and many others in aid of food production (Tilson et al., 2010; Smith, 2018). As data obtained from farms expands due to the use of machines and sensors, farming will gradually become data driven Wolfert et al., (2017:7).

Precision farming (PF) has been described by Wolf and Buttel (1996:1269) as the application of GPS georeferencing technology on farms to retrieve data and navigation. Eastwood et al., (2017b:1) defined PF as a phenomenon where GPS systems innovation of sensors are used to automate farm work and record the performance of farm animals. For example, sensors used to connect a mechanized drip irrigation system for farming or a manned drone applying fertilizer on the farm. Digital agriculture on the other hand is the use of in-depth digital information to guide decisions along the agriculture value chain (Shepherd et al., 2018:17). While Eastwood et al., (2017:742) see smart agriculture to encompass both digital and precision agriculture, Wolfert et al., (2017:70) think that precision agriculture requires only "taking in-field variability into account" while smart agriculture advances ahead by using data to manage events not only location, "enhanced by context -and situation awareness, triggered by real-time events." Notwithstanding the terms used, digitalization uses several data to manage activities on-farm and off-farm, be it weather, location, prices, economic information, drone, satellites, machines to monitor soil, water, plants, animals and human beings (Klerkx et al., 2019:2; Eastwood 2012:10). The operation of digital agriculture requires the use of Big Data. Big Data has been defined as a sort of data huge that traditional data processing applications are not enough (Wolfert et al., 2017:70). Boyd and Crawford (2012:665) opined that Big Data does not refer only to a large set of data and the process of manipulating them, but a computational turn in reasoning and research. Boyd and Crawford added that information is stored in data which is used to monitor activities on and off the farm.

For this paper, I would classify all terms used as digitalization of agriculture[1]. However, within the Sub-Saharan African perspective, digitalization is being slowly adopted through

[1] The words Digital Agriculture, Digital farming, and Digital technology are used interchangeably for the purpose of this work.

mobile phone applications and other less complex devices for agricultural production provided by communication companies and digital platforms.

2.2. Potentials of Digital technology

Digitalization of agriculture has been promised to be able to provide a variety of problems faced by the society in the area of food to cater for the increasing population of the world, reducing the impact of farming on the environment, ensuring the safety of food through traceability (Wolfert et al., 2017). Digital agriculture is expected to address challenges confronting food production like climate change that is deepening the food insecurity situation in the world. Digital technology is expected to help solve this shortfall in food sufficiency.

There has being a plethora of development research literature on the potential benefits of digitalization in the form of mobile phone adoption and use by farmers in developing countries. As the world population is projected to increase to over 9.8 billion by 2050, there is a challenge of meeting the food needs of the growing population (Trendov et al., 2019). Some think this increase would need an increase in food production from developing economies, accompanied with the use of technology by farmers to make precise decisions equipped with information on water, soil, climate and crops (Paul et al., 2019). While others may disagree with this, it has been claimed in a report by Panel, (2019:11), that digital technologies could assist increase production while 'ensuring sustainability' and providing employment within the value chain. Further, it has been observed that small scale farmers account for a major part of agriculture in developing countries and play a crucial role in maintaining genetic diversity of food, and reducing the risk of nutritional inadequacies and degradation of the ecosystem (Paul et al., 2019:1). However, they face many problems such as pressures on farms due to urbanization, climate change and inability to rely on generational knowledge, Precision agriculture is thus a new development that could help farmers make decisions to address these challenges (Paul et al., 2019). Moreover, digital agriculture is seen to be able to address these challenges such as food security, environmental impact, productivity, and sustainability (Kamilaris et al., (2017:23).

Consequently, in trying to address the challenges in food production, many governments, mobile phone companies, donors and nongovernmental organizations see mobile phones as a tool for economic development (Aker and Mbiti, 2010:220). The spread of smart phones and remote sensing and computing services have shown to be creating new opportunities to incorporate small scale farmers into the new digital agrifood systems (Trendov et al., 2019:1) and can increase communication to improve market and productive efficiency of firms to manage supply chains Aker and Mbiti, (2010:214). Digitalization for agriculture could help reduce the impact of climate change through improvement in the use of resources, employment in agricultural technology, as well as promoting inclusiveness among women farmers and other marginalized groups (Tsan et al., 2019; mittal, 2016). Similarly, the use of mobile phones in agriculture has been demonstrated to improve the provision of information by reducing knowledge gap among farmers across gender and promoting awareness on new technologies and best practices (Mittal, 2016:202; Owusu et al., 2017).

In terms of the finances, studies have shown some potentials of digital technology. Some studies in Sub-Saharan Africa show that ICT has the capacity to provide farmers access to information and market linkages and allow the ability to collect data and facilitate access to financial services (Aker, 2016:35). It also has the capacity to enhance the provision of agricultural, financial, educational and health services (Aker and Mbiti, 2010:214). In Ghana, digital technology in the form of mobile money provides opportunity for formal agribusinesses to be able to pay farmers when purchasing crops in the agriculture value chain (Loukos and Javed, 2018:7). It has also been observed that, the use of mobile based technology could

help increase farmers income by obtaining market information, weather, and production information, if the necessary capacity is provided (Owusu et al. 2017:42). Further, Mobile money offers agribusinesses the opportunity to handle the inadequacies of managing physical cash and encourage saving habits (Loukos and Javed, 2018:23).

Lastly, some studies in sub-Saharan Africa see the use of digital technology as likely to improve agriculture along the value chain. Studies carried out in Kenya have shown that many problems limit the ability of small-scale farmers in Africa to have access to markets, such as lack of information and capacity. However, the integration of ICT among smallholders has helped to resolve these challenges (Okello et al., 2010). Another study by Furuholt and Matotay, (2011) carried out in Babati district of Tanzania shows that the use of ICT has helped farmers in the peripheries to access market and increased opportunities across the agricultural value chain. Similar research carried out in Ghana show that ICT applications are used for connecting players within the agriculture value chain, price information, linking buyers and sellers, facilitating transport and enhancing the effectivity of other important information services within the value chain (Debrah and Asaare, 2013:689). Debrah and Asaare observed that ICT applications has resulted in increased incomes, however its sustainability is difficult to overcome unless stakeholders in the value chain focus on certain parameters such as business scope and planning.

2.3. Shortfalls

While literature on digital technology has shown some potentials, many have observed that the adoption of technology has forced small scale farmers to become dependent on inputs manufactured by multinational corporations such as Syngenta and Bayer (Harris and Stewart (2015:45). Studies have also questioned the economic sustainability of these mobile-based information delivery models in light of the fact that it is externally funded, and farmers are not paying for the information they receive (Mittal, 2016). As confirmed by Tsan et al., (2019:22), some companies rely on donors for the funding to try out different brands of business that their customers and financiers are interested in. Other questions have also been raised in studies done in Kenya regarding sustainability in terms of the economic ways of maintaining the IoT technology and the workforce that form the ecosystem because it is reliant on funding (Paul et al., 2020:8). Further, some journals have made observations on the infrastructural and institutional bottlenecks confronting the new technology. Ekweke (2017) argues that, while digitalization is promising and making farming lucrative for young people, the development of applications is not enough to "feed Africa" because there are institutional and infrastructural challenges that need to be improved to transform Africa's agriculture. According to him, traditional organic farmers are initially resisting the use chemical fertilizer as they fear it will have a long-term negative impact on their farmlands. On the issue of infrastructure in Kenya, for example, Paul et al., (2020) identified problems of equity and access of data, low smart phones penetration, complicated ecosystem, access to components, poor connectivity, and remoteness of locations as challenges to digitalization.

2.4. Data, ownership, and use

Despite many success stories scientific literature has highlighted on digitalization, additional concerns are increasingly raised by social scientists regarding the use of data and its implication on the relations in agri-food with respect to the future of farming. These issues address

the case of Ghana in which a proliferation of tech companies is being seen profiling data of small-scale farmers. Data is obtained from the field and installed in software which provide information on soil moisture content, humidity, temperature, and others (Kaloxylos et al., 2013:168). In a similar fashion, Big Data is changing traditional mode of agriculture through information in crop production and extensive weather data which are the backbone of precision agriculture (Carolan, 2018). With this increasing use of data, digitalization in the financial sector is building infrastructure to obtain profit from new emerging markets of Africa (Mann, 2018:13). She added that microcredit and payment coordinators are building platforms while Balance of Payment gives a business plan as well as an ideological justification. On the other hand, Carbonell (2016:2) indicated that agribusiness like Monsanto value Big Data because they provide to them a chance to construct predictive business models across different aspects of farms. The critical questions about Big Data are: why are big tech companies so much interested in data? Who is Big Data going to assist to make better services, tools, and public goods? Will data intrude privacy and introduce marketing? (Boyd and Crawford, 2012:663). If economic transformation is the driver of social development, then what matters is who implements the system, who owns the data and who is being encouraged to learn the innovation (Mann, 2018:5). Fraser (2019:894) describes this as the new capitalist accumulation which is heavily tied with activities from tech giants such as Apple, Google, and Amazon. This stems from the fact data obtained becomes the property of tech companies and is used for their own gains. Scholz called it the sharing economy where new distributors obtain "profits out of previously un-monetized interactions, creating new forms of hyper-exploitation, and spreading precarity throughout the workforce (Scholz, 2016:1).

2.5. Digital agriculture as a power relation

The use of Big Data in farming can alter the roles and power relations among different actors across the food supply chain networks (Wolfert et al., 2017; Carolan, 2017; Bronson and Knezevic, 2016; Carbonell, 2016). In trying to understand the stake holder network in digital farming Wolfert et al., (2017) observed that the roles of old and new software providers continue to change regarding Big Data and farming. Moreover, companies like Google, and International Business Machines assume prominent roles and as prospects for Big Data emerge within agribusiness, Major companies like John Deere and Monsanto have invested heavily on technologies that deal with data of different seeds, type of soil and weather to assist farmers cut cost of production and increase production (Wolfert et al., 2017).

Whereas corporations engage seriously in Big Data and agriculture, digital startups are busily facilitating and providing various solutions across the chain, starting from infrastructure to sensors and to software that manages data on the farm (Wolfert et al., 2017). Further,

> "as ag-tech space heats up, an increasing number of small tech start-ups are launching products giving their bigger counterparts a run for their money" (Wolfert et al., 2017:75).

They describe them as "a swarm of data service startups". In this case digital startups like Farmbot and Climate Corporation obtain their products from tech giants such as Google and Amazon and to provide services to famers.

Bronson and Knezevic (2016) have also observed that the collection, aggregation and analysis of data using digital tools might affect the relationship between different actors within the food and agriculture value chain. They argue that Big Data produces long-term relationship between farmers and corporations, therefore more research needs to be done because the impact of Big Data and its social structures are not in place. According to Wolfert et al., (2017), the chain consists of stakeholders that interact with powerful tech

companies, entrepreneurs, small startups, and new entrants. Also, there are other public institutions that publish data with conditions of ensuring that privacy of people is safe guarded.

Chapter 3: Theoretical Framework and Methodological Strategies

In this chapter, the theoretical perspectives and the methodological strategies are discussed. It is made up of two sections, section one deals with the theories while section two consists of the methodology.

3.1. Political Economy

> "Capitalist accumulation in the contemporary period is heavily bound up with action emanating from a 'tech' sector led by firms such as Apple, Alphabet (the owner of Google) and Amazon." (Fraser, 2019:894).

Political economy to technology studies examines how the rules, power and institutions related to digitalization changes and reproduces (Klerkx et al., 2019), and the balance of power governing the system and impacting on different players, and the responses that arise and including the ethics surrounding data privacy and ownership and its management (Klerkx et al., 2019 :5).[2] This paper makes use of the work of Bronson and Knezevic, (2016) on how Big Data acquisition has the capability of creating disputes between actors (farmers and corporations) in food and agriculture. According to Bronson and Knezevic, collecting data could benefit more corporations than farmers, as well as have some possible ethical implications. The study considers the problems relating to farm data ownership, privacy and the benefits accruing from it as stressed by Wolfert et al., (2017).

This work is mindful of the need for broader legal and regulatory frameworks surrounding the use of farmers data, as highlighted by Wiseman et al., (2019:2). Wiseman et al., (2019) identified the concerns farmers have on their data, regarding the sharing and usage. They therefore stressed on putting the right broader legal frameworks, laws on agricultural data, like licenses and laws regarding privacy.

Further, Carolan's work put more insights on how digital platforms shape structures and governance on food (Carolan, 2017). This work pays critical attention to digital platforms and their role in the food value chain as pointed out by Carolan.

This work also takes into account the ethical issues regarding the use of new technologies in farming. The use of new technology raises many ethical questions since it involves many human actors, notably,

> "what would be good, right, just, required or acceptable action to do, or what societal goals are worth striving for" (Van der Burg et al., 2019:1).

I try to interrogate weather and how new technologies and innovation are being responsible and take 'societal values' into consideration at the early stages of development. Additionally, the issue of 'data grab' in early stages of adoption is keenly taken note of. As observed by Fraser, in fact, the use of PA technologies for monitoring, mapping, and managing of farming activities while data is produced for service providers who bring forth the analysis can be seen as data grab in the Global North (Fraser, 2019:879).

Additionally, since Transnational Corporations play a vital role in digitalization to open the market for agro-inputs, I also refer to the work of Weis (2007:44) on how TNC's are decreasing the capability of smallholder farms by replacing labor with technology and

[2] For details of theoretical and methodological perspectives in Digital Agriculture see Klerkx et al., (2019).

changing their production conditions. Further, engaging the work of Greene and Joseph, (2015). I try to make a critical examination on how the geography of capitalism continue to exploit labor by changing forms, as well as the way new organizations and technologies shape this exploitation.

This research takes a critically consideration of the work of Thatcher et al., (2016). Thatcher et al, see Big Data as a commodity where uneven power relations between individuals leads to a dispossession of data generated on daily basis. They argue further that unevenness of data capture is a process of capitalist 'accumulation by dispossession' and continuous commodification. At last, the research considers the role of Financialization in agri-food paying attention on how it is reshaping agrarian growth and food systems (Clapp and Isakson, 2018). Clapp and Isakson argues that financialization within the agri-food sector has widened new areas for 'capital accumulation', that have changed food firms to suit the demands of shareholders and transformed how food is provided to the society.

3.2. Knowledge and Innovation Systems

This paper also draws from Agricultural Innovation Systems approach, (Fielke, et al., 2019:1) and tries to consider the impacts of digital innovation processes that are crucial to transforming agriculture by modifying the risk and taking advantage of the gains. Fielke et al., (2019) argue that digitalization has already had an impact on agriculture and will continue to do so, therefore due to the number of stake holders involve in transmitting the technology, it has implication for policy. Agriculture knowledge and Innovation System also try to consider implications for the duties and skills of farmers, from the people that offer advice to them, including data analyst and institutions that create the connections (Ingram and Maye, 2020:2). This work is mindful of how digital agriculture interferes with 'established modes of knowing and decision making', although this interaction between technology and society breeds tension in agriculture decision making but also allow for synergy (Ingram and Maye, 2020).

3.3 Methodological strategies and methods of collecting data

This section entails the methods, techniques and procedures employed for the collection of data and the analysis.

3.3.1. Case Studies

I adopt here the case study method in order to allow for an in-depth investigation on the experiences of small-scale farmers interaction with digital technology. The approach of case study emerged out of the need to understand the complexity of social phenomenon and, its 'natural' context (Miller and Brewer, 2003:22). Case study methodology is

> "an empirical inquiry about a contemporary phenomenon (e.g., a "case"), set within its real-world context especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 2011:4).

According to O'Leary, case study

> "allows for the building of holistic understandings through prolonged engagement and the development of rapport and trust within a clearly defined and highly relevant context" (O'Leary, 2014:195).

Data was obtained through different sources. The aim is to obtain multiple sources of information to create rigor. As argued by Yin for any case study data to be relevant, it should not

come from one source but a multiple source of evidence (Yin, 2011:4). Therefore, Case study employs triangulation to investigate cases by drawing from multiple sources of evidence, such as field observation, historical, field research, textual, and process-tracing. (Gerring, 2006:17).

The choice of case studies stems from the fact that the research assistant will not have to move around the country. Case study usually involve a reduction in cost of travel because the study is located at specific site, access to respondents is higher which allows for higher engagement to establish trust in defined context (O'Leary, 2014:195). Since I had limited time and funds for the research, case study was the appropriate choice. It is important to mention that the research was carried out with the help of a Research Assistant (RA). The medium of communication used was WhatsApp calls (audio, text messages and video) and Zoom video calls. The researcher also employed different types of data from various sources including, surveys, field observation, interviews from both farmers and extension agents, as well as secondary data from policy documents, blog post, and news items. This was to enable triangulation from different sources to ensure rigor of the study.

3.3.2. Study Population and Sampling Procedure

The population of study consist of small-scale cocoa farmers from the East Akyem municipality of the Eastern region of Ghana. They are farmers who have been registered and are receiving advisory services through their mobile phones from Esoko digital platform while some work under Agroecom company at the same time.

3.3.3. Sampling Procedure

Among the farmers that receive advisory services from Esoko platform in the region, 30 cocoa farmers were selected from East Akyem municipality for the survey. Out of the 30 farmers, 15 each were selected from Tafo and Mase communities. Among the farmers from Maase, 5 were also on the Agro-ecom programme in the district. Eight farmers and one extension agent were interviewed, as well as an informal interaction with one officer from Esoko. A purposeful sampling technique was used to select respondents.[3]

> "Purposive sampling is described as a random selection of sampling units within the segment of the population with the most information on the characteristic of interest" (Guarte and Barrios, 2006:277).

The aim is to engage with farmers who obtain services directly from corporate platform (Esoko). Respondents were identified through the platform. Due to the busy nature of cocoa farmers especially during the rainy season, they were not easily accessible for the interviews and therefore a snowball sampling technique was employed to make contacts with other farmers for the interviews. A key informant was identified by the RA among the farmers. The RA was also another key informant, this is by virtue of his experience, knowledge, and in the field under research.

3.3.4. Secondary Data

The study also used secondary data or text from different sources. A manual on Ghana's e-Agriculture was obtained from the ministry of agriculture, news items and reports on Ghana's digitalization agenda was reviewed. Also, the study made use of GSMA 2018 report on last mile digitization, a document on a profile about Esoko was also reviewed including

[3] For details of all respondents interviewed see Appendix 3 for details

the company's blog post. Blog of Agro-ecom, IFC, Farmerline and Esoko were interrogated as well. Other reports on digital financial services were also interrogated, I also sourced from articles, and news websites.

3.3.5. Data Analysis

The quantitative data obtained through the survey was analyzed using statistical package for social science research (SPSS). Before the data obtained from the field was analyzed, it was scrutinized for missing values and unanswered questions, and outliers before it was entered on SPSS for analysis. As regards the qualitative data, after the interviews the data were transcribed, codes were assigned to categories to identify the main themes. Thematic analysis was employed linking the main themes to concepts and theories to build deeper understanding.

3.3.6. Positionality, political choice, and ethical considerations

According to O'Leary (2014) the responsibility of shaping knowledge lies with researchers; therefore, it is prudent to consider and recognise ethical and political awareness in conducting research. He posits that

> "researchers must actively manage power, politics and ethics" (O'Leary, 2014:48).

As a researcher, you possess power and authority over small-scale farmers because you sought to control them by virtue of the position you hold as a person conducting the research.

I therefore recognise my position as a person who has worked as a research assistant with Innovation for Poverty Action for 3 years in rural farming communities, a person undertaking master's degree abroad, my own values and believes as a farmer for 10 years helped me shape my thinking of different aspects of this work. Besides, Crossa, (2012:126) argued that positionality should not be related to only issues emerging from the field, but the ideas that emanate from accessing various literature. I employed the concepts, theories, and methodologies I have learnt from the MA program in analysing this work. More importantly, I identify the multiplicity of ways to negotiate the different aspect of power that exist between 'the researcher, the Research Assistant and the researched' and make a balance to produce this work.

Also, my position from the rural background, familiarity with the customs and traditions, the language and knowledge of the geographical location to a large extent play a tremendous part in facilitating the progress of this work. Although I was not physically present in the field, the virtues highlighted above came to bare during the online interaction through the Research Assistant. These virtues assisted in establishing a good rapport with farmers which started the research with ease. My ability to interact using the local language and terms peculiar to cocoa farmers made them comfortable without doubting my identity, coupled with the introduction made by the Research Assistant that a was a student established trust with the farmers.

As a procedure for every research, professional standards and protocols were adhered to, consent of participants was sought, after declaring the aims and objectives of the study to them. Participants were told they can freely withdraw from the study at any point in time if they become uncomfortable. The confidentiality and anonymity of participants information were safeguarded and concealed throughout the process. Also, the research assistant signed a consent form which outlined the regulations regarding the study which bind him to observe a such.

3.3.7. The Research Assistant

As mentioned previously, this study was carried out with the help of a research assistant, the reason been the inability of the researcher to travel to the study area due to the Covid-19 pandemic. The RA holds a bachelor's degree in Agricultural Education, the RA is an agriculture extension agent working under the Ghana Cocoa Board in East Akyem district for three years. My choice of the RA stems from the fact that, the RA had previous experience with working with cocoa farmers and has knowledge on food production and other issues across the value chain. In addition, the RA is also familiar with the study area and some farmers as well, aspect which facilitated the interaction during the survey and in obtaining vital information which were needed in answering the research questions.

The RA was able to make initial contacts with respondents after I gave the RA contacts of respondents from Esoko. He also identified a key informant among the farmers and farmers under Agro-ecom while contacting the agricultural extension agent for an interview. The entire survey was conducted by the RA with my assistance through online WhatsApp calls. We worked hand in hand throughout the data collection process. Each time he found it difficult to phrase a question he called me, and we discussed. Before each survey he sought for consent and after completing he called me, for me to thank the respondent. The RA coordinated all the nine interviews I conducted online with farmers on the field through WhatsApp calls (both normal audio calls and video calls). The RA also carried out field observation on how farmers operate their phones, marketing of farm produce, mobile money transfer, and inputs received from Agro-ecom, cues and expressions from respondents.

The impact of the RA in the research process should be noted as Research Assistants are active participants, their positionality therefore should be recognised as such (Ozano and Khatri, 2018:191). According to Edwards and Alexander (2011:276) the researcher is always an 'outsider' while the RA is an 'insider'. They stressed that power relations exist between the researcher and the RA which cannot be disregarded but be acknowledged. They argued further that this relation is multidimensional and 'fluid' and not straight forward, power keeps changing throughout the research process, it favours the researcher during the employment process and 'conceptualization' and favours the RA during collection of data (Edwards and Alexander 2011:276-277). Considering the role played by the RA in this study, as an insider, he had power to conduct surveys and identify respondents for interviews. However, I conducted the interviews while the RA only played a coordinating role. This there avoided the possibility of the RA putting his own views or providing leading answers especially during interviews as stated by Edwards and Alexander, (2011:72). Moreover, I carried out the transcription due to my ability to speak the language which also avoided any personal bias or additional information that the RA could have incorporated into the work.

My ability to recognise this power shifts between myself and the RA has played a role in shaping this work.

3.3.8. Scope, limitations, and challenges

The study explored the effects of digital technologies on small-scale farming in the Eastern region of Ghana. It focuses on the Maase and Tafo communities in the East Akim municipality where Esoko provides digital services to small-scale farmers. Firstly, the thing that limited this study was the inability to investigate other areas in Ashanti region reached by Farmerline, which could have enriched the data by making a comparative analysis. This was due to time and resource constraints that limited my ability to explore a wider area. Besides, my inability to travel to Ghana because of Covid-19 pandemic influenced my decision to solely rely on the help of my research assistant.

Moreover, gaining access to small-scale farmers using digital technologies in their farm work was very challenging. For example, at the beginning, I sent two emails to Farmerline digital platform without getting any response. I followed up with WhatsApp messages through their office line but to no avail. I then made someone to visit their office to find out if they could grant us access to the farmers, they are working with to conduct a research. On two occasions he was not given the chance to see the officer responsible with the excuse that he was busy. It was then that I took a different route by approaching Esoko. When Esoko was contacted, they provided their terms and wanted to take part in conducting the research, they also provided a budget that seemed like a big project way beyond the capacity of student research. I was not comfortable with that proposal but opted only for them to help me contact the farmers while my research assistant conducts the survey. I also paid the cost of using their digital software and for having access to the contact of farmers from their data base.

Another challenge faced during the study was the online sessions which were mostly interviews and interactions with respondents. During the online interviews, there were frequent disruption of internet link. There were instances where the research assistant had to wait for long at a respondent's place just to re-establish internet connection for an interview. However, the research assistant was able to always arrange a place for farmers where there was a good link for interviews to be carried out. The study was carried out during farming season therefore the research assistant had to travel long distances to farms to conduct surveys. The research assistant had a motor accident on one of such travels, but fortunately, it was not fatal. He received treatment and resumed after a week.

Finally, policy documents were difficult to obtain from MOFA, as well as officials for interviews. The study therefore relied on the only few documents available.

3.3.9 Study Area

The research was conducted in East Akim municipality in the eastern region of Ghana. Two communities (Mase and Tafo) were selected for the case study because they were provided digital enabled services by Esoko. East Akim municipality has an estimated land area of about 725 km^2 located in the central portion of the region bounded by six districts. West Akim to the north-west, Atiwa to the north, Fanteakwa to the west, New Juaben to the south, Yilo Krobo to the east and Suhum Kraboa-Coaltar district to the west. It has a total population of 167,896 according to the 2010 population and housing census (GSS, 2014).

The economic activities in the district include agriculture, mining, tourism, agro-processing, and crafts. Agriculture in the district form 57% of the economic activities according to the 2010 population and housing census, out of this 92% are crop farmers while the rest are poultry and livestock (GSS, 2014).

The municipality is located within the semi-equatorial climatic zone and moist semi-deciduous forest vegetation. The municipality is characterized by two main rainfall seasons (double rainfall maxima), the first season starts from May-June and the second occurring between September and October. The dry season also starts between November and late February and are distinct. The relative humidity is high throughout the year ranging between 70%-80% during the dry season and between 75%-80% in the wet season.

Figure 1: Map of Ghana showing the study area

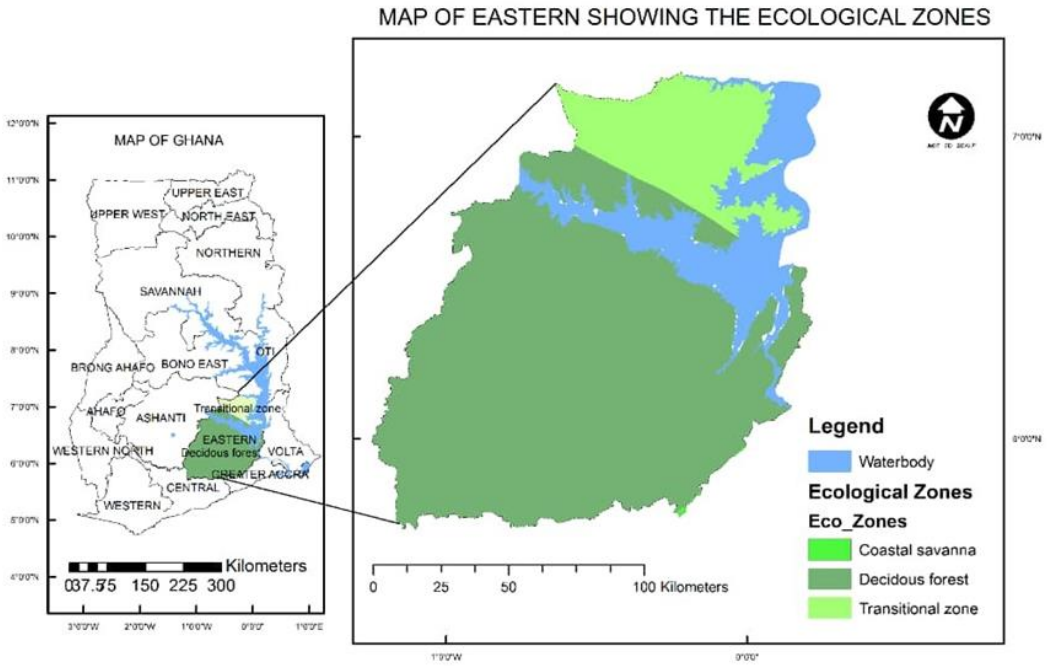

Figure 2. Municipal Map showing study communities

Source: East Akim Municipal Assembly (2020).

Image 1: Shows a small-scale family harvesting cocoa beans in Ghana in Eastern region

Source. Field work, 2020

Chapter 4: Digital Technology and Small-scale farmers Interaction

4.1. Demographic and Socio-economies Characteristics of Respondents

4.1.1. Age Distribution of Respondents

The majority of the respondents were between the ages of 30 and 49 years representing 83.3%. (see Table 4.1) Few of them (6.6%) were below thirty (30) years and 16.7% were above fifty (50) years.

Table 4.1. Age Distribution of Respondents

Age(years)	Frequency	Percentage (%)	Cumulative (%)
18-29	2	6.6	6.7
30-39	9	30	36.6
40-49	14	46.7	83.3
50-59	5	16.7	100
Total	30	100	100

Source**:** Field Survey Data, 2020.

Respondents are in the economically active age group. Nung, (1996) noted that physical strength or weakness of an individual determines the age of retirement. This explains why a few aged respondents are still found working in the study area.

4.1.2. Sex Distribution of Respondent

Most of the respondents were males (representing 70% of the sample), versus a 30% female. (Table 4.2). There was therefore no form of gender bias in selecting the respondents.

Table 4.2. Sex Distribution of Respondent

Sex	Frequency	Percentage (%)	Cumulative (%)
Male	21	70	70
Female	9	30	100
Total	30	100	100

Source: Field Survey Data, 2020

4.1.3. Marital Status of Respondents

As shown in the Table 4.3, many of the respondents were married (63.3%). Few 16.7% were either divorced or widowed the rest (20%) were single.

Table 4.3. Distribution of Respondents by marital status

Marital Status	Frequency	Percentage (%)	Cumulative(%)
Single	6	20	20
Married	19	63.3	83.3
Divorced	3	10	93.3
Widowed	2	6.7	100
Total	30	100	100

Source: Field Survey Data, 2020.

The study suggests that although they may have a lot of family responsibilities, married respondents can assist each other in mobile phone operation in adopting digital technology since they always work together on the family farm. Moreover, some married couple could be using a single phone which is good for the sharing of ideas on mobile apps.

4.1.4. Educational Level of Respondents

Results in Table 4.4 show that (87.7%) of respondents have had formal education. Only few (13,3%) had no formal education.

Table 4.4. Educational level of Respondents

Level of Education	Frequency	Percentage (%)	Cumulative (%)
No Formal Education	4	13.3	13.3
Basic	15	50	63.3
Secondary	11	36.7	100
Total	30	100	100

Source: Field Survey Data, 2020.

The fact that the majority of the respondent have some degree of formal education which might help their ability to operate mobile application with little issues. Eisemon (1992) indicated that education affect the way people think and solve problems. According to World Bank, (1999), formal education increases farmers capacity to create and innovate Moreover, farmers with high level of education are more open to new technologies and could be early adopters of innovation since they could read and write about the innovation (FAO, 2005).The high literacy rate among respondents is expected enhance receiving and decoding of information and adoption of technologies (van de Ban and Hawkins, 1998).

4.1.5. Land Holdings of Respondents

The majority of respondents (82%) had land holdings between two and ten acres (four hectares). Few of them (17.9%) had landholdings above that.

Table 4.5. Land Holding Distribution of Respondents. Note: 1 hectare = 2.471 acres

Land holding (Acres)	Frequency	Percentage (%)	Cumulative (%)
1-5	13	46.4	46.4
6-10	10	35.7	82.1
11-15	5	17.9	100
Total	28	100	100

Source: Field Survey Data, 2020.

According to Khalil et al., (2017) there is no single definition of who a smallholder[4] is, however, the most popular off all criteria used is land size. World Bank in Khalil et al., (2017:7) see smallholdings as those with small property base and working in less than 2 hectares of farmland.

Table 5 shows that the average land holding of the surveyed farmers is 6.4 acres (which is 2.6 hectares), meaning they mostly fall within the category of smallholder farmers. While some farmers may have land of size exceeding the defined land size of two hectares, they may fall within other criteria used to categorize smallholders such as labour, technology, access to market and economic size of the land. According to observations made by the Research Assistant, the farmers within this study rely only on family members for labor, have low technology to support production, and have difficulty accessing the market for other food crops apart from cocoa. These and other conditions may categorize them as small-scale farmers and not only land size.[5]

4.2. The role of the state in digital Agriculture

In Ghana, the ministry of food and agriculture (MOFA) is the institution responsible for ensuring the development of the food sector. The mission of the ministry is to

"promote sustainable agriculture and thriving agribusiness through research and technology development, effective extension and other support services to farmers, processors and traders for improved livelihood" (MOFA, 2019).

As part of its mission to develop technology, the state launched an agenda in 2016 to digitize many sectors of the economy, including agriculture. Since then many programmes have been launched to try to implement this agenda. One of such programmes is the West Africa Agriculture Productivity Programme (WAAPP). It is a pilot project on "electronic extension of agriculture technical service to farmers and other actors in the agriculture sector through a web portal, Digital photography and GPS assisted smartphone applications were launched through a collaboration between Ministry of Food and Agriculture (MOFA) and World Bank (MOFA, 2019). Based on the success of the pilot project, the state decided to implement the e-Agriculture platform to enhance information and technology to improve the agriculture value chain and to meet the Sustainable Development Goal (SDG) 2 of Zero Hunger and Millennium Development Goal (MDG) number 8 of Global Partnership for Development. MOFA's priorities for the e-Agriculture platform include, developing

[4] Small-scale farmer and Smallholder farmer refer to the same entity although small-scale is more on the level of production while smallholder refer to the tenure system Khalil et al., (2019).

[5] Based on the tenure system in Ghana, farmers can own large parcels of land and still be regarded as small-scale farmers because of other conditions, they also perceived themselves as such.

networks for information and knowledge exchange, capacity building in rural areas, increasing access to market information and farming techniques, improving access to scientific and technical information and improving access to data for policy decision (MOFA, 2019). A Study on mobile use in rural Ghana identified low technical capacity, lack of and access to information as key areas to consider in enhancing ICT among smallholder farmers (Owusu et al, 2017). Therefore, MOFA's priorities seems to be on course to patching these technological deficits. Moreover, the priority on accessing data for policy decisions may be a step in the right direction because some work done in Zambia proofs that smart phone apps could be a reliable tool for data collection among smallholder farming systems (Daum et al., 2018). However, my review of the Manual and MOFA's website observed that, many issues that are necessary for sectors adopting digital technologies at an early stage are missing. Taking the work of Wiseman et al., (2019) into consideration, there need to be broader legal and regulatory framework concerning the use of farmers data. There seems to be no such framework governing the states' digital agenda on agriculture. MOFA's mission of modernising agriculture through technology is likely to affect tacit indigenous knowledge of farmers if there are no plans to build a synergy by recognising tacit knowledge as postulated by Ingram and Maye, (2020). In as much as the state is promoting partnerships with private institutions to promote digitalization, it must be mindful of some ethical concerns posed by new technologies due to the numerous actors involved as indicated by Van der Burg et al. (2019). This is especially related to the case of Esoko where the state has facilitated the work of Esoko to obtain data from farmers with little or no ethical considerations.

4.3. Digitalization within the agriculture value chain

I employ the theory of political economy and knowledge and innovation systems to try to make an analysis of the findings from the interviews, survey, texts, documents review, and field observations carried out in the field.

This section will examine digitalization based on two cases, the service provided Esoko and the activities of Agro-ecom. My review of corporate texts in a digital brochure for clients obtained from Esoko, and text from their blog post and interactions with some staff of Esoko indicates that most of these digital 'start-ups' have similar data collecting tools like those being acquired by Monsanto. Confirming what has been argued by Wolfert et al., (2017), digital 'start ups' are facilitating and developing solutions across the supply chain ranging from infrastructure to software that manages data from the farm, as new startups emerge, they give corporations bigger returns by using their products.

Esoko has been operating in Ghana since 2008 providing mobile agriculture solutions for smallholder farmers. It first started by offering a software tool that aimed at collecting and providing market prices of goods and later added other content like weather forecast, crop and nutrition advices to farmers. It is now a management platform which provides digital tools for "profiling, communication and service delivery such as content, input financing, market access and insurance" (Esoko, 2020). A text from the broucher state,

> "Launched in Ghana in 2008, Esoko has successfully innovated at the forefront of mobile agriculture solutions for smallholder farmers & won many awards" (Esoko, 2020).

Its services span three core areas all address one integrated platform. These areas include first, digital farmer services, second, data digitalization services and analytics for agribusiness (insyt) and, third, customized registration/survey programs (CRiSP) (Esoko, 2020).

During my interaction with an officer[6] from Esoko, He claimed that the digital farmer service (DFS) is the package for small-scale farmers, and is aimed at empowering communities with digital inclusion initiatives by providing information about market and climate information via SMS and voice. The webpage also confirmed that Esoko undertake biometric registration and GIS mapping of farmers for government subsidies. This was formalized by a contract with the Ministry of Food and Agriculture (MOFA) aimed at gathering names, age, fingerprints, crops, farm size and location and other data of farmers for the ministry. It further provides credit and insurance to smallholder farmers via 'Esokowallet' and Visa payment solutions, providing guaranteed and structured market outlet for smallholder farmers, for example linking farmers to supermarkets in the cities and exporters via the Platform, access to mechanization service, providing inputs on discount and providing credit to informal workers (workers not in government payroll) and distributing information to farmers in Ghana (Esoko, 2020). Esoko claims it target population to constitute of poor communities because it sees digitalization as a way of developing these communities. The platform is operating in 20 countries in Africa. It works with many organizations across the world, including, Prestat, Carana corporation, Wienco agriculture, International Finance corporation (IFC), Climate Change Agriculture and Food Security (CCAFS), AECOM, Toto agriculture, telecom company Vodafone, and many others (Esoko, 2020).

> "Esoko has been helping enterprises manage rural communities since 2008. Traditionally focussed on content services to farmers, the platform now provides powerful data collection & digitization tools, biometric profiling, analytics, as well as communication services. And we are introducing additional services like digital credit, insurance, payments and transactional services." (Esoko, 2020).

In Ghana, many digital platforms have emerged in the past years that provide various services like Esoko, such as Farmerline, Cowtribe, AgroCenta, and others. The case of Esoko in this study will provide insights into how these platforms operate, but it is worth briefly describing another large platform, Farmerline in order, to situate the Esoko platform.

A report by Loukos and Javed reveals that Farmerline provides services to farmers as Esoko. According to Loukos and Javed (2018;18), Farmerline has built a tool that assists agribusiness to undertake digital gathering of data, farmer profiling, management and analytics for field monitoring, farm mapping and procurement of produce. In addition, the digital tool is used by agribusiness to provide training to farmers and its enables auditing farmers for compliance and certification such as through Rainforest Alliance and Fairtrade and can conduct voice surveys with famers in different languages (Loukos and Javed, 2018). Its activities are: providing digital identity and financial records of farmers, training farmers on improved farming practices and business tips through digital channels like voice calls talking books, providing weather updates in local languages to farmers, supplying farm inputs on credit to farmers and undertaking distribution of these inputs (Farmerline, 2020). These activities are executed using a Mergdata a web and mobile application that is used to power numerous farmers across Africa, using modules for farmer profiling, certification, traceability, mapping, messaging, and digital payments (Farmerline, 2020). It has an affiliation with multinational cocoa firms including, the world cocoa foundation, and the Hershey company. A careful comparison of these two platforms reveals a similar 'modus operandi'. Farmerline also operates in cocoa communities located in the same climatic zone as Esoko, the two Platforms have external links with large organizations and corporations in and outside of the country. I describe their existence in the digital technological terrain as competitive due to the wide array of services they provide within the agro-food sector.

[6] Some identities are hidden for purpose of anonymity

4.4. Esoko Farmer Services

An informal conversation with an officer from Esoko reveals that, the farmer services provides digital information on weather forecast and commodity pricing to farmers on weekly bases through their mobile phones. Based on an interview with the agriculture extension agent in the district, Esoko supplements their services by sending messages about weather and commodity pricing to farmers. Also, all respondents 86% confirmed to receiving both text and voice messages, although they do not know the source. Further investigation by the research reveal the messages was from Esoko. All respondents 100% confirmed that they benefit from digital technology. With regards to the weather, messages are sent to farmers regarding what to expect over one-week period. It provides farmers information on what to expert in the coming in the coming days regarding the weather, which enables them to plan their activities in terms harvesting, drying of crops such as cocoa, maize, and rice and harvesting as described by the extension agent above. This was confirmed by a farmer who benefits from the weather information he receives in his agricultural activities.

> "(…) the rain is unpredictable especially in the wet season, if you want to dry cocoa beans and go to farm and there is no one around, it may get wet on your return but through the weather messages you will know the appropriate time to dry them" (Interview Ofori 29-10-2020).

Image 2. Ofori and son drying cocoa beans using weather information

Source. Field work 2020

A report by the Malabo Montpellier Panel showed that most farmers in sub-Saharan Africa continue to rely on indigenous knowledge about the weather because they do not have access to reliable information about weather (Panel, 2019:7). Weather messages sent to farmers by Esoko are likely to overcome this information shortfall. This reminds of the work of Kaloxylos et al., (2013), where they posits that data from the field could be obtained and installed in hardware to provide the farmers with information such as the weather, soil moisture content and others.

Further, Esoko also provides updates on prices of various agriculture commodities for both national and regional levels. Farmers, however, receive only updates within their regional location. The update includes prices of various food stuffs in some major markets in the region are useful for farmers to know the best price to sell their products and the preferred market they wish to send their produce to. (Extension agent 11-10-2020). It is important to

note that the price of cocoa is determined by the Ghana Cocoa Board. There is a ready market for cocoa beans where Licensed Buying Companies (LBC's) have their representatives stationed at various locations in the districts purchasing them. Therefore, the price information from Esoko only covers other food crops such as plantain, rice, cassava, maize, and others. This is confirmed by the regular market updates Esoko provides captured through one of Ghana's news portals Ghanaweb.

> "From its Esoko's April survey, there was a hike of 28.84% in the price of cassava to close the month at ¢124.33 per bag with tomato also making a gain of 24.18% per crate to close at ¢826. Pona, a variety of yam, gained 22.11% to close at ¢814.67 per 100 tubers". Ghanaweb (07-05-2020).

Farmers mostly do not get the actual prices for their produce even though they are considerable, middlemen obtain the produce at 'farm gate prices' and sell it at high prices at urban centers and benefitting from the struggle that the farmer go through (Oguoma et al., 2010:78). While access to information may provide market opportunity for farmers to sell their produce, Aker et al., (2016:36) indicates that where markets are scattered coupled with poor transportation, farmers are not likely to benefit from the information due to their inability to obtain transport to market centers. The commodity pricing provided by Esoko is likely to empower farmers with information, however, the benefit from market information to farmers will largely depend on the means to reaching these markets.

4.5. Farmer data profiling

Before Esoko started to engage with the farmers within the catchment area in 2017, first a survey was carried out by Esoko to obtain biometric data such as names, fingerprints, age, and farm data of all farmers. Surprisingly, most surveyed farmers indicated they had never heard of a platform by name Esoko. Although Esoko sends weekly weather forecast and market information through mobile applications, many farmers were not aware that the messages and voice mails they receive on their mobile phones were provided by Esoko. From the survey, respondents were asked whether they receive messages, 86% admitted to receiving both voice and text messages, however, none acknowledged to receiving it from Esoko. In trying to find out how Esoko obtains the data of farmers in providing the services they are currently transmitting; I held an interview with Opoku an extension agent from the agricultural department in the district. Opoku explains how Esoko accessed data of farmers in the district.

> "We were giving a training in the office on how to register the farmers by our director before starting the actual work (…) it was on house to house basis where personal details of farmers like names, crops, farm size, number of livestock or poultry, GPS location were recorded, phone number and fingerprints (…) registration is still ongoing for farmers that were not captured during the exercise (…) the information is then sent to their database in Accra".
>
> (Opoku, 11-10-2020) Field interview.

According to Opoku, they assisted in collecting the data alongside staff of Esoko. Since the activity was initiated by the Ministry of Food and Agriculture, the officer at the municipal level must be involved. An enquiry in the blog of Esoko indicates that the data collected was used for government subsidies to farmers in parts of the country. Information from the key informant indicates that, subsidized inputs are distributed by officers from the agricultural departed in the municipality directly to farmers every growing season. However, farmer societies can register for their members.

> "In 2017, Esoko was contracted to collect biometric and spatial data of 200,000 farmers; recruit and supervise 400 field agents; and provide a real-time reporting dashboard for the ministry to make data-driven decisions on input subsidies" (Esoko, 2020).

According to Esoko it was meant for the 'Planting for Food and Jobs' programme by the Ministry of Food and Agriculture (MOFA) aimed at profiling farmers to create a national data base for Ghana. This would have enabled the government to easily implement input subsidy for farmers under the program (Esoko, 2020).

It was through this exercise that Esoko had the opportunity of accessing data of farmers which is used in sending the messages on weather and commodity pricing. This confirms the assertion by Kaloxylos et al., (2013) that data from the field is being used to provide the farmers with information such as the weather, soil moisture content and others. More importantly, Esoko developed a smart mobile phone application called Insyt for collecting real time field data. The app assists researchers in collecting socioeconomic, agricultural, and other data accurately and has analytic features for analyzing data collected (Esoko, 2020). According to a study done by Daum et al., (2018) in Zambia, smart mobile apps can provide a chance for researchers to collect data about small-scale farming systems, by reducing costs and increasing accuracy. Also, my research work relied on the Insyt app in gathering the field data from Esoko (conducted by the Research Assistant).

The conversation with Opoku showed that the consent of farmers was not sought before the exercise was carried out. When the state is involved, farmers usually expect that they are going to benefit from it, and as a result, generally they do not question the process. Also, from the survey no respondent answered the question, are you aware of any Digital Platform, this means farmers did not know Esoko. In using Big data in farming, Wolfert et al., (2017) is concerned about data privacy, ownership, and beneficiaries. They stressed that where farmers data is going to be used for business purposes, they must have knowledge and an agreement made before data can be transferred to other stakeholders because farmers own data. Moreover, this also reminds the concerns of ethics in obtaining such data as highlighted by Klerx et al., (2019).

One critical issue to note is that Esoko provide a wide range of integrated activities ranging from digital services to farmers to business analytics and survey programs. It may be that these data obtained from farmers is likely to be used for other businesses for its clients considering the many organizations they partner with. Notably, some of these organizations are widely known to be involved in input manufacturing for example Wienco, Toto agriculture is Big Data Analytics, while Carana Corporation is Development Consultants). Again, coupled with Esoko's business plan of 'helping enterprises manage rural communities and linking smallholder farmers to businesses', data obtained is likely to be provided to companies for business management purposes. Therefore, services such as weather and market information giving to farmers may not be the company's priority.

Further, this could be linked to what Fraser described as 'data grab' at the early stages of adoption of Precision Agriculture technologies where companies and government agencies gather data from customers (Fraser, 2019:895). More importantly, Wiseman et al., (2019) also stress the need for a broader regulatory framework surrounding the use of farmers' data. Esoko undoubtedly, provide information services through its mobile applications, however, in their quest to provide weather and market information to farmers, they could take an opportunity to profile the data of farmers for business purposes. Regarding ownership of data, the farmers are far from owning data since there was no formal agreement with terms and conditions between farmers and Esoko to profile its data and provide them with services. Evidently, from the survey, respondents were asked: What are the terms and conditions in accessing the services? No respondent answered, this confirms there was no agreement before data was obtained. According to interviews with farmers, they believed it was the usual

exercise carried out by the agriculture department and have no idea what the implications would be. While the state may be using the data for its programme and Esoko also providing services with data, the data is not owned by farmers because they have no idea what it means to them. This reminds of the questions, who owns data generated from farmers and who benefits from such data (Wolfert et al., 2017). It is unethical to extract data from farmers without revealing your motives and not sharing part of the benefits that accrue from using such data. My attempt to undertake this research was to have access to farmers under Esoko's digital services, which I was provided through their data base. It is an undeniable fact that many actors seeking to obtain such information could have access to it through Esoko since they confirmed it on their advertisement or 'business mission'.

> "So if you're looking to profile or register people, digitize agric supply chains & social protection programs, conduct GIS mapping, or to track inventory or impact, or if you want to engage communities with critical information campaigns like healthcare, agronomic advisories, climate smart contents, weather, nutrition or market information, Esoko's the way to go!" (Esoko, 2020).

Esoko could therefore benefit from sharing such data while the farmer would have no idea.

In similar fashion, interview with farmers indicate that Agroecom company within the district carry out the profiling of farmers. Based on information on Agroecoms' blog and some news items and from the blog of International Finance Corporation (IFC), who partner them, they purchase cocoa beans on large scale and carry out data collection of farmers. The evidence below shows how data is collected from the field,

> "(…) this biodiversity data was cross-analyzed with data already gathered on production, farm practices and farmers' socio-economic profiles." (IFC, 2020).

Considering the work done by Fraser, the use of PA technologies in mapping, monitoring, and managing activities of farmers and using this data to provide services is the grabbing of data (Fraser, 2019). Besides, the provision of farm inputs and loan facilities to farmers has further reduce the role of farmers to only production. Data is a commodity and its generation on daily basis creates uneven power relations between individuals that could lead to dispossession (Thatcher et al., 2016). Thatcher et al. see the continuous capture of data as capitalist 'accumulation by dispossession' and a continuous commodification of production. Although digital technology in the East Akim municipality is at early stage, the activities of corporations could rip cocoa farmers from benefiting from the technology in the long run. Indeed, the passing of the Plant Breeders Act in 2013 could provide opportunity for Agro-ecom[7] to research on cocoa seeds and develop new breeds for farmers as Ghana. Although new variety of seeds could improve yield and resistance, it could also deepen the dependency margin of farmers because they will rely solely on Agroecom for their seeds.

4.6. Activities of Agro-ecom in the cocoa value chain

The research identified some players within the cocoa input and output circuits. They include, small-scale farmers, licensed buying companies, input providers and Ghana cocoa board. The Cocoa board is the government institution that regulate the prices of cocoa for both producers and buyers. Table 4.6 depicts the licensed cocoa buyers within the study area,

[7] The names Agro-ecom and Amajaro mean the same, Amajaro is popular among farmers although it has been merged

Table 4.6: Licensed Buying Companies (LBC's) in Study Area

Company	Origin
Olam	local
Produce Buying Company	local
Akuapa	local
Agro-ecom	International

Source. Field work, 2020.

The focus of this study is primarily on Agro-ecom, the reason being that it undertakes digitization of farmers data and their products and provide them with inputs and other services. According to the key informant, Agro-ecom was previously Amajaro before merging with another company. Agro-ecom operates a scheme where farmers are selected, trained, and registered under them. The key informant indicated that farmers under the scheme are often provided with farm inputs such as fertilizer, herbicides, and knapsack sprayers on credit to support them in production, farmers are also certified and sell their cocoa produce to Agro-ecom exclusively. The cost of inputs is deducted from the farmers' produce and the remaining balance is paid to them. The study reveals an increase in the use of inputs due to information they receive from their mobile phones. On how digital applications influence their use of chemicals, 73% indicated strongly increased use, while 27% indicated increased use. This means that the input supplied to farmers by Agroecom may be have some links to digital technology.

Again, farmers are provided loan facilities from Agro-ecom for production and after harvesting the loan is deducted from the sales at the purchasing station and the balance is paid to farmers. Nana (11-09-2020) When asked what the role of Agroecom in the cocoa supply chain is, a farmer who works as a purchasing clerk (PC) for Agro-ecom replied:

> "I have worked with Agro-ecom for four years as a PC (…) farmers are usually selected and trained on agronomic practices and inputs application and provided with certificates. Their farms are then surveyed and mapped digitally with GPS and other tools. This will enable them to have full details of all farmers and their farms under their program. Agro-ecom provides inputs to farmers in the growing season on credit, diseased trees are reported at any time and treated. I usually buy beans from farmers during harvesting season and transport it to the District Organizer (DO) who then bag them and transport it to the harbor for the head of the company before they are exported. They provide premium to farmers every year during purchasing. We buy cocoa beans from only their certified farmers and the cost of inputs are deducted from their produce and the remaining balance is paid to them through mobile money transfer or cash. They also give loans; we call it funding because you will be allowed to pay it gradually. The D.O (District Organizer) approve the funding to farmers…" Major (29-09-2020) field interview.

Although the Ghanaian case is in the Global South, Amajaro seems to confirm the claim, made by Bronson and Knezevic (2016) looking at the power relations in the Global North, that corporations are likely to benefit more from the data obtained than small-scale farmers.

Further corroboration through search on the company website confirms that they are one of the largest global buyers of Ghanaian cocoa beans. As stated on the website of International Finance Corporation (IFC, 2020), they also,

> "implement sustainability programs and community initiatives for thousands of small holder farmers". Further, Amajaro "worked with biodiversity to develop a rapid biodiversity assessment (RBA) methodology to capture data on plant biodiversity in cocoa farms … they then compile the data into a geographic information system implemented by their existing Traceability and Mapping System (TMS) (IFC, 2020).

I would like to put a spotlight on a similar trend of activities which is undertaken by Cargill in some cocoa communities in the western region of Ghana. This is not meant to make a structured comparison but to unmask some of the major players operating within the cocoa value chain using digital technology. In 2016 Cargill acquired a license to buy cocoa directly from farmers. It's purchasing model comprises two pillars which include, partnering with network provider MTN to pay farmers digitally through channels like MTN, TIGO and E-Zwich and also ensuring the certification of all cocoa purchased by the company (Loukos and Javed, 2019:15-16). According to the report Cargill jointly with MTN, are campaigning to register and profile farmers for digital payments beside providing agronomic advice to farmer groups during planting to implement sustainability certification schemes and at the end farmers who perform well are given premium for cocoa beans sold under the scheme. Inputs and training are also provided to farmers to restore their farms by replacing low productive trees with quality and resilient seedlings (Loukos and Javed, 2018). Consequently, cocoa beans that are bought are weighed digitally and designated a traceable bar code and paid digitally using mobile money through Unstructured Supplementary Service Data (USSD) communications technology by purchasing clerks (Loukos and Javed, 2018:15).

4.7. Other Sources of information for farmers

The study gathered that there are many existing sources of information that farmers can obtain with regards to their activities. It was revealed during observation by the RA that many of the farmers keep referring to other sources they interact with for information. They receive information on daily basis from extension agents and through the media platforms which are radio and television stations and farmer groups. Agriculture information is always broadcasted in their local languages from the municipal, regional and national TV and radio channels. Some confirmed that advertisement and demonstration on how to apply newly introduced fertilizer and spraying of diseased cocoa is often shown on television stations and social media. From the survey, 50% heard of digital platforms through television, radio and extension officers, 27% heard through TV and radio, 13% heard through Extension officers and TV, 7% heard through TV,radio and social media, while 3% heard from only extension officers.

Further, farmer associations are source of information that has much influence on farmers activities although it has not been listed as a source from which farmers heard of digital technology. The associations are usually made up of members of a particular community undertaking similar production like cocoa. Their basic objectives are taking care for the welfare of its members, providing loans (susu), and communal labor, and sharing of new ideas in farming. Ofori, one of the farmers interviewed indicated that he has being obtaining loans from his association for the past 5 years because he does not have a bank account to enable him to access a loan. Importantly, all the farmers that have being surveyed and interviewed belong to an association. The extension agent also hinted that banks usually open accounts for associations but not individual farmers, therefore in accessing a loan facility, individual farmers could borrow from their associations. (a farmer from interview).

Table 4.7: List of farmers and their Associations

Name of farmer	Gender	Name of Association/Group
Nana	M	Nyame Bekyere cocoa farmers & marketing society
Kwame	F	Adukrom Biakoye cocoa farmers & marketing society
Akua	M	Adukrom Akyem women cocoa farmers & marketing society
Agyeman	M	Agye Nyame cocoa farmers and marketing society
Ofori	M	Agye Nyame cocoa farmers and marketing society
James	M	Agye Nyame cocoa farmers and marketing society
Kojo	M	Nimdea cocoa farmers and marketing society
Major	M	Agye Nyame cocoa farmers and marketing society

Source: Filed work, (2020).[8]

Another most important source of influence among the farmers is the agriculture extension agents. They serve as a major source of information and represent the main mediators between government policies and the farmers. In my interview with the extension agent, I asked how digital technology is assisting in extension services.

> "(...) the smart phone helps a lot, now, farmers can call directly and get prophylactic treatment. We call that e-extension (…) farmers can approach you in advance at any time instead of waiting for the weekday for you to come round. I also have a WhatsApp platform for all the farmers that have android phones where I send latest information (...)" Opoku, 11-10-2020 field interview.

This clearly show that the use of the mobile phone has enhanced information delivery as posits by Aker, (2016). The use of digital technology keeps extension agent in touch with farmers remotely. This can also save cost of travel and improve efficiency. According Opoku diseased crops are captured on phones and sent directly for feedback on what to do.

It is worth nothing that, interviews with farmers shows that among all these sources of information, the agriculture extension agents are the most important source of information to farmers, it is closely followed by farmer associations and the electronic media (TV and radio) respectively.

4.8. Challenges faced by small-scale farmers in accessing digital technology

The study also revealed some bottlenecks hampering farmers attempt to utilize the opportunity in digital agriculture. The survey showed that 80% of respondents complained of poor network connection, high cost of data, and call credit whiles 20% complain of only poor network connection. This goes to confirm studies done in Kenya by Paul et al., (2020), that

[8] For reasons of anonymity, the names provided here are for the purpose of this study only

poor infrastructure and connectivity and remoteness of location affect digitalization. They lamented of too much deduction of credit which is becoming a burden for them. They added that this causes delay in receiving information and sending and receiving money. Field observation discovered that most farmers cannot operate their phones very well, this is more particularly related to illiteracy. For example, many of them cannot locate the application for voice mails. Those who attended education up to secondary level are able to manipulate better than the illiterates. This slows down the ability to adopt the technology. Besides, information alone may not be enough to drive production if farmers do not have the ability to receive and use it for their benefit.

High costs of data connection for small-scale farmers may risk the technology of its sustainability in rural communities since farmers may not be able to keep up with the costs. This situation will only favor the rich farmers further creating a digital divide. Similarly, poor infrastructural network in the community is due to the low population density found there as recounted by the agricultural extension agent in the area.

> "(…) they Telco's consider the number of customers in the area before extending their service (…) the population in this community too is low". Opoku, (11-10-2020). Field interview

Considering the cost involve, Telco's would rather conduct a cost benefit analysis before installing networks in rural communities. This would have a detrimental effect on farmers and denying them the benefits of digital technology.

4.9. Effects of digital technologies on farmers autonomy and Indigenous knowledge

Many of the articles in the development literature have paid little attention to how digital technology could affect farmers' autonomy and lead to dependency. The provision of digital services by Esoko and the related activities carried out by Agro-ecom has had some impact on farmers across the value chain. Although it might usually take some time to realize this impact, farmers indicated that to some extent they feel the influence of these services in their daily activities.

Esoko usually send weekly advisory services to farmers in the form of weather and market updates through SMS and voicemails. In the past, small-scale farmers often relied on their own knowledge to predict the weather in planning their activities, though it was difficult and not reliable since the rainfall pattern keeps changing year after year. All farmers responded yes when asked if digital technology has changed their previous way of farming, and 86% confirmed that the information help them to adapt to the weather. On the level of influence in the use of agricultural inputs such as fertilizer, improved seeds, and other chemicals for plants protections, all the farmers indicated a strong increase in use. When respondents were asked if they are combining the new technology and their own skills in farming, 90% answered yes while 10% answered no. To the question of why, 13% said to adapt to the weather, 40% said to overcome weather change, 13% did not answer while 3% said to cope with weather. It is clear here that, 'tension' may be taking place. Indigenous knowledge versus knowledge acquired through mobile advisory services. Ingram and Maye, (2020) postulates that digital agriculture interfere with traditional knowledge of farmers in decision making and this can cause tension. However, a balance can be reached. This study shows there seems to be a balance in decision making among small-scale farmers as they are adopting the two practices to adapt to the weather.

Further, the use of farmers data in providing services to them by Agro-ecom such as funding, inputs, training, and certification has the capacity of not only denying them of their autonomy but could make them become dependent on their services. Based on the survey, all farmers 100% indicate an increased input use due to digital technology. On the influence of credit providers on farm decisions, all farmers 100% said credit providers are extremely influential on decisions on farming. Considering the work of Clapp and Isakson (2018) on how financialization in agro food sector is reshaping agrarian growth and food systems, the funding of cocoa farmers could expand Agro-ecom's 'capital accumulation' and change farmers means of providing their food in the long run. Cocoa farms could be expanded to the neglect of food crops affecting food security. They may eventually become more powerful in terms of relations in the chain.

Regarding the level of influence of digital technology in the use of agricultural inputs such as fertilizer, improved seeds, and other chemicals for plants protections, all the surveyed farmers indicated a strong increase in use. Harris and Stewart, (2015) observed that technology has forced some farmers to become dependent on input manufactured by multinational corporations. This increased use of inputs by farmers provided by Amajaro is likely to lead to dependency. Also, an inquiry into the company's blog confirm that they manufacture agro inputs. The key informant Nana (11-09-2020) reaffirmed that they receive inputs such as fertilizer, pesticides, cutlass and sometimes seeds from Amajaro. Farmers operating under the programme rely more on Amajaro for agronomic advice, spraying of disease crops and sale of their cocoa beans. For example, the key informant gave an account on how diseased crops are dealt with.

> "(...) every farmer must report any diseased cocoa tree to Agro-ecom by taking a picture with a mobile phone and sending it to them for any instruction for treatment" Nana, (11-09-2020). Field interview

Image 3. Cocoa infected with black pod disease captured by a farmer to be reported to Agroecom for treatment.

Field work 2020

This means the farmer has no authority to undertake any decision on the affected plant but to rely on expect advice from the company. It is important to note that the training and certification organized by Agroecom to farmers will help farmers improve their production by increasing yield, nonetheless, it undermines the knowledge of indigenous farmers who have inherited tacit knowledge from earlier generations and are still in the business. Moreover, their principle not to buy beans from uncertified cocoa farmers shows the level of disregard for traditional knowledge, because cocoa production has survived all these years due to indigenous farmers.

4.10 Digital financial services (DFS) and its effects on small scale farmers

> "Mobile money is a fast, convenient, secure and affordable way of transferring money, making payments and doing other transactions using a mobile phone" Nicco-Annan, (2020: No page).

The introduction of digital financial services popularly known as mobile money has come to enable money transfers, payments, and financial services in general to users of which small-scale farmers are no exception. Mobile money providers in Ghana include, MTN, AirtelTigo, and Vodafone. Since its introduction in 2009, the Bank of Ghana published an Economic and Financial data where active mobile money accounts are 14.7 million and 235,000 active agents Nicco-Annan, (2020). Mobile money providers in Ghana have played an important role in the agriculture supply chain by extending digital financial services to those at the lower level of the chain (Loukos and Javed, 2018:22). Although farmers in the study area not been registered under any model like the case of Cargill and MTN in the western region, mobile money offer them the only opportunity of financial transaction. According to the research assistant all farmers surveyed are registered under mobile money. They are either registered on MTN, AirtelTigo or Vodafone depending on the available network connection in their area. Mobile money registration is widely known and simple, one need a valid national ID

card or passport to be able to register with an authorized mobile money merchant in your catchment area.

During the interview, a female farmer was asked why she did not operate a bank account, and she admitted that there are no banks or financial institutions closer therefore the only option is the mobile money. Akua, stressed that mobile money is good alternative for her, as she put here:

> "As for me I prefer mobile money, those who go to the banks in town often delay the whole day. If you need money urgently to solve your problems, you cannot get it immediately (…) with mobile money, you are able to receive and pay for something if you are even on your farm (…) sometimes my cocoa sales are paid through mobile money for safety reasons" Akua, 10-09-2020. Field interview.

The use of ICT can be a tool that will provide access to credit, inputs and create trust between farmers and stake holders across the value chain (Panel M.M., 2019:10). Mobile money is particularly helpful to Akua being a female because she will be able to transact business across the value chain. It is not surprising to know from the location that there are no financial institutions, this may account for the reasons why most of them do not own bank accounts but rather subscribe to mobile money accounts. A report by Buruku, (2020) reveal that about 42% of Ghanaian adults have no formal financial accounts. This may account for the increase in mobile money users among farmers. Also, a report by Caron, (2020) in Kenya, indicated that DFS could be a way of providing financial access to small-scale farmers in rural areas.

As discussed earlier in the literature, the use of ICT has been cited to facilitate financial services among farmers (Aker and Mbiti, 2010). Mobile phones also promote inclusiveness among marginalized group of people (Tsan et al., 2019). Considering the plight of these farmers, they find themselves in a disadvantage location where banks and other services are lacking. Mobile phones therefore serve as the only solution to bridging that development gap. Field observations by the RA revealed mobile money serves as an avenue for saving for many farmers and that will usually be used as a precondition for securing credit from most creditors and finance companies.

Chapter 5: Conclusion

5.1.1: Conclusion

In this research paper, I attempted to identify the ways in which digital technology affect small-scale production. In doing so, I have attempted to explore the effects of digital technology on the autonomy and indigenous knowledge of farmers, investigate how data is obtained and used from small-scale farmers and who benefits from it, and understand how digital financial services affect small-scale production. With regards to the effects of digital technology on farmers autonomy and indigenous knowledge, I have found that the use of digital technology is likely to decrease the ability of small-scale farmers to apply knowledge that has been passed onto them by previous generations. The reason is that information obtained from digital technology have interfered with farmers own knowledge in production. Farmers, however, try to create a balance by combining both knowledge obtained through digital technology and their indigenous knowledge in terms of adapting to climate change. In terms of autonomy, I have also found that information provided to farmers through digital means tends to make small-scale farmers more dependent on the technology providers for production. In terms of how data is obtained and used from small-scale farmers and who benefits from it, the study found that privacy surrounding data acquisition postulated by Klerkx et al., (2019) and Wolfert et al., (2017), were not respected and followed in obtaining data from small-scale farmers. In terms of data usage, both digital platform Esoko and Agroecom companies used data obtained from farmers to provide services to farmers. However, Esoko uses data of farmers to link farmers to different actors within the agriculture value chain for business while Agroecom uses data of farmers for research to determine the right inputs for farmers. Moreover, the benefits of data accrued to tech providers more than the small-scale farmers confirming the work of Bronson and Knezevic, (2016). In reference to how digital financial services affect small-scale production, the study found that digital technology has enhanced access to financial tools, promoting so-called 'financial inclusion' among small-scale farmers which facilitated marketing of their products across the value chain.

The study also found that limited digital infrastructure, connectivity, high cost of data and lack of technical capacity of farmers are the challenges limiting farmers from fully accessing or benefiting from digitalization. Besides, other avenues of information for farmers was also found, they include, farmer associations, electronic media (TV and radio), and extension agents. Among these, extension agents were found to be one that provided most information, followed by farmer associations before electronic media (TV and radio). This suggest that we should not overestimate the current impact of digitalization for information provision.

The role of the state has been found to have an impact on digitalization. The state has an agenda for digitalization by partnering with private entities to provide digital services to farmers. However, it lacks the necessary regulatory framework for governance of the activities especially of platforms and corporations, which could have implications since Ghana is at an early stage of adoption.

On the whole, digital technology provides a vital source of information to farmers which enhances both their production, in terms of access to inputs, extension and marketing of agricultural products, however, younger and educated farmers are able to maneuver and benefits more than the older once.

It is important to note that, the methodology employed could not obtain a large data set (survey) to generalize this study on the wider area of Ghana. I would therefore recommend

a deeper study in future on the response to digital technology across the agriculture sub-sectors and other stakeholders involved. This would show how digital information received through these phone impacts on agriculture. This study could also provide insights on digital technology for broader research and policy making in the area of agriculture in Ghana.

5.1.2: Policy Recommendations

For farmers to fully benefit from digitalization of agriculture across the value chain to foster socio-economic progress, the following policy guidelines need to be looked at to develop a sustainable strategy that meet the needs of all actors.

Firstly, the state must put digital agriculture as a national agenda backed by an act, this act should contain all rules and regulatory framework on digital governance where the ministry of food and agriculture would enforce them. Secondly, instituting education and training programs to all actors across the value chain and to empower farmers on digital tools. Additionally, the state should increase investment in digital infrastructure in the country. Lastly, the state could adopt digital technology tools and innovations that would meet local needs.

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Appendices

Appendix:1. Questionnaire for small-scale farmers of East Akim Municipality

The researcher is undertaking this survey to fulfil the requirements for the award of a master's degree at Erasmus University. The main purpose of this questionnaire is to investigate how digital technology is transforming small-scale farming and the issues that arise. This research will ensure the confidentiality and anonymity of participants. Thank you for taking part in this research.

Demographic characteristics

1. What is your age? a. 18-29 ☐ b. 30-3☐ c.40-☐ d.50☐ e. 60 and above ☐
2. Gender a. Male ☐ b. Female ☐
3. What is your marital status? a. Married☐ b. Single☐ c. Divorced ☐ d. widowed ☐

   e. other…….
4. Which members of your family work on the farm?.....
5. What is your highest level of education a. Basic ☐ b. secondary ☐ c. Bachelor ☐ d. master's ☐ e. Other ☐
6. Do you speak/ or understand English? a. yes ☐ b. no ☐
7. Are you the owner of the farm or are you managing it for someone else? a. owner ☐ b. not owner ☐
   i) If you are not the owner of the farm, what kind of person is owning it? a. Local owner farmer ☐ b. local businessman ☐ c. owner in nearby town ☐ c. Owner in regional or national capital ☐
8. How much land belongs to your farm? … …… hectare/s……..
9. What livestock do you have, if any? a. none ☐ b. yes ☐ namely: [indicate numbers]

Horses:…Cows:… Pigs:….Goats:…Sheep:….Chickens/ (or other birds):…….other…….

10. What type(s) of crops do you grow throughout the year? a. Root/tubers ☐ b. Cereals/grains☐ c. fruits/vegetables ☐ d. other, namely:…….)]
11. What are the sources of income to your family?

a) Non-farm wage work, namely:……...b) work at another farm ☐ c) self-employed namely:…….

12. Which is the main source of income? …….
13. How long have you been farming?.....

Farmers knowledge and use of digital technology

14. Do you own a mobile phone? a. yes ☐ b. no ☐

15. If NO: What person helps you to access digital technologies, if at all? a. household member b. fellow villager c. an extension officer d. an employee of Esoko e. staff of cooperative/association f. other(specify)…….
16. What type of phone? a. conventional phone ☐ b. smart phone ☐
17. How often do you use your mobile phone? a. less than once a day b. 1-5 times a day c. 5-10 times a day c. more than 10 times a day
18. Mention some of the things you do with your mobile phone?.....
19. Mobile phones/ applications assist me in my farm work? a. Strongly agree ☐ b. agree ☐ c. disagree ☐ d. strongly disagree ☐
20. What are the apps/services you mostly use? ……
21. Have you ever received a voice message/mail or text message on your phone?

a. yes, both ☐ b. only text messages ☐ c. only voice mail ☐ c. none ☐

22. Which information do you receive on your phone? Information about: a. weather ☐ b. market ☐ c. credit/loans ☐ d. extension services ☐ e. inputs f. other (specify)……..
23. Have you heard about digital platforms/services? a. yes ☐ b.no ☐
24. How did you hear about them? …….
25. For how long have you been registered with them (if any at all)?.....
26. What services did you register to obtain? a. weather ☐ b. market information ☐ c. mobile money/ credit ☐ d. extension services ☐ e. other(specify)…….....
27. Why did you subscribe to the service?.....
28. How beneficial is the information you receive to your farm work? a. extremely beneficial ☐ b. very beneficial ☐ c. beneficial ☐ d. not beneficial ☐ e. don't know ☐
29. What benefits do you think you can obtain from the service? …….
30. Do you pay for the services? a. yes ☐ b. no ☐
31. What are the terms and conditions in accessing the services?

Are you aware of any of them? If so, please specify……

32. Which digital device do you have apart from a mobile phone?.....
33. Do Digital applications improve farming activities in your farm? a. yes ☐ b. no ☐

If yes to Q31, how? a. very strongly ☐ b. strongly ☐ c. a bit ☐ e. no change ☐ f. other (specify)…….

34. Do you experience challenges in using the technology? a. yes, very much ☐ b. yes, a little

c. no ☐

35. What are some of the challenges you face in using the technology?.....
36. How do you think the government can do to help overcome these challenges?.....
37. Are you member of a cooperative, association or out growers arrangement?
38. If YES: What digital services does it provide itself or in collaboration with Esoko/tech-company?

Effect of technology on farmers Autonomy

39. Has digital technology changed the farming practices you previously applied in farming?

a. yes ☐ b. no ☐

40. If yes to Q37, in what ways? Tick all that apply: a. improved knowledge of weather ☐ b. change of planting season (in adaptation to climate) ☐ c. soil moisture content ☐ d. change from using local knowledge ☐ e. increase in yields f. increased use of inputs, f. more precise use of inputs g. improved food storage ☐ h. other……..
41. How have digital applications influenced your use of fertilizer, chemical plant protection (pesticides, herbicides, insecticides) improved seeds, in farming?

a. strongly increased use ☐ b. increased use ☐ c. no change ☐ d. bit decrease use ☐ c. strongly decrease use

42. Has the use of digital technology influenced you to adopt products (inputs) and methods to replace the local ones that you previously used? A. yes☐ b. no ☐
43. What do they give you?.....
44. Are you combining the new technology and your own skills in faming? a. yes ☐ b.no ☐
45. If yes, why, and how? ……..
46. How have the new products and methods affected your own knowledge in farming? a. improved knowledge strongly ☐ b. improved knowledge a bit ☐ c. no influence ☐ d.reduce my knowledge a bit ☐ e. reduced my knowledge strongly ☐
47. How do digital applications affect you to be flexible in farming (e.g. change crops, or rotations)? a. much more flexible ☐ b. a bit more flexible ☐ c. no influence d. a bit less flexible e. much less flexible
48. Would you want to go back to traditional ways of farming? yes ☐ , no ☐ and is it possible? Yes ☐ , no ☐

Credit and its effects on farmers

49. How do you normally access credit/loan? a. micro credit b. bank c. mobile money d. susu scheme e. other (specify)…….
50. Have the use of digital application/technology helped you to access loan? a. yes ☐ b. no ☐
51. It is easy to access loan through digital applications (technology)? a. strongly agree ☐ b. agree☐ c. disagree☐ d. strongly disagree☐
52. Loans provided through digital platforms have flexible terms and conditions a. strongly agree ☐ b. agree ☐ c. disagree ☐ d. strongly disagree☐

53. What item (property) do you use as collateral before accessing the credit?.....
54. Have credit providers any influence on your decisions in farming? a. extremely influential ☐ b. very influential ☐ c. influential d. not influential
55. Have you ever defaulted in paying back a loan? a. yes ☐ b. no ☐
56. What happens if you are unable to pay?.....

Appendix 2: Interview guide for Farmers

1. Have you heard of the use digital technology in farming?
   a. Probe: What do you know about digital farming?
   b. Probe: Which application do you use and how does it work?
   c. Probe: How did you know about digital technology in farming and how did you subscribe to it?
2. How beneficial is it to you in farming?
   a. Probe: what services do you get from the application?
   b. What benefits do you expect from accessing the technology?
   c. Probe: How long have you been on the subscription and how long do you intend to use the application?
3. What are the terms and conditions in subscribing to the application?
   a. Probe: What are the costs involved in using the technology?
4. a. Do technology providers make profiles of your farms and produce?

b. Probe: Are you aware of what they do with such profiles or inventory?

c. Do they assure you of the privacy of your profiles and that it will not be given out to the public or any individuals or group?

5. What are the challenges you face in using the application?
   a. Probe: Do the challenges affect your farming activities and how?
   b. Probe: How can these challenges be addressed?
6. How does digital application affect your indigenous knowledge of farming?
   a. Probe: Has the technology changed your approach to farming and how?
   b. Probe: which aspect of your indigenous knowledge of farming does digital technology try to replace?
   c. Probe: do the terms and conditions in subscribing to the technology affect your autonomy (independence of choice of farming)
   d. Have digital applications introduced new (or more) products (inputs) to you and what are the products?
   e. Has new products and inputs introduced to you affect your own skills/ideas in farming?
   f. Can you continue farming without using digital technology and the products that come with it?
7. Have you received any financial support (loan) with the aid of digital applications (technology) for farming and in what way?
   a. What are the terms and condition in accessing the finance (loans)?

b. Probe**:** Does finance (loans) you obtain for farming influence your autonomy in farming (in terms of choice of the type farming)?

c. Probe: How does it affect your productivity?

d. Probe: How does credit affect control of resources (power relations)?

e. What happens if you are unable to pay back loans?

Agriculture Extension agents

1. What do you know about digital technology?

Probe: What types of digital technology are used by farmers in your district?

Probe: How do farmers access these technologies?

Probe: How does digital technology enhance farming in terms of agriculture extension?

2. Is government introducing digital technology in farming?

Probe: what is the role of government in digital farming?

3. What are the challenges faced by farmers in adopting and using digital technology?

Probe: what are the possible measures taken by government to address these challenges?

Probe: Is the government concerned about how data is obtained, and the security and privacy of data obtained from farmers and what strategy is government putting in place to address the issue?

Probe: Do you have a governance framework on data and what is government's role in ensuring that private entities abide by the framework?

Digital platform (Esoko)

1. What motivated you into providing digital services or applications?
2. What type of services do you provide and how do the applications operate?
3. What type of data do you obtain from farmers to provide them the services?

Probe: How is the data stored and who owns the data?

Probe: what are the terms and conditions in obtaining data from farmers?

Probe: How is the data managed?

Probe: What strategies do you put in place to protect the privacy of farmers and how do they benefit from it.

4. What are the challenges you face in providing digital technology to farmers?

Probe: what are the infrastructural challenges?

Probe: Do you have insurance cover for the services you provide?

Probe: what do you think can be done to improve digital technology?

Probe: Do you have partners local or international that support you and what activities are they engaged in?

Probe: How do you see digital technology in farming the next 10 years?

Probe: Is the use of digital technology economically sustainable among farmers in Ghana?

Appendix 3: List of farmers interviewed

Name of farmer	Age group	Gender	Name of Association/Group	Date interviewed
Nana	30-39	M	Nyame Bekyere cocoa farmers and marketing society	11-09-2020
Akua	30-39	F	Adukrom Akyem women cocoa farmers and marketing society	10-09-2020
Kwame	50-59	M	Adukrom Biakoye cocoa farmers and marketing society	10-09-2020
Agyeman	40-49	M	Agye Nyame cocoa farmers and marketing society	12-09-2020
Ofori	40-49	M	Agye Nyame cocoa farmers and marketing society	15-09-2020
James	40-49	M	Agye Nyame cocoa farmers and marketing society	15-09-2020
Kojo	30-39	M	Nimdea cocoa farmers & marketing society	12-09-2020
Major	30-39	M	Agye Nyame cocoa farmers and marketing society	29-09-2020
Opoku	40-49	M	Agric Extension Agent	11-10-2020
Officer 1	30-39	M	Esoko	16-06-2020

Source: Filed work, (2020).