



Digitalizing agriculture and the improvement of farming business practices: How rural farmers in Ghana employ mobile phone technology

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Digitalizing agriculture and the improvement of farming business practices: How rural farmers in Ghana employ mobile phone technology

Abstract

Purpose

This purpose of this paper is to explore how rural farmers in the Kwahu district of Ghana use mobile phone technology, what they see as the benefits of digitalization and how this technology supports and improves their small business agricultural practices.

Design/methodology/approach

A qualitative research approach draws upon in-depth semi-structured interviews with 24 rural farmers, 12 of whom are given farming advice by the Ministry of Food and Agriculture and 12 by a non-governmental electronic market body which, in addition, provides training in mobile phone technology use. Thematic analysis is used to identify key findings.

Findings

Farmers identify improved customer and agricultural benefits as well as family access as the key benefits of using mobile phone technology, enabling them to change their farming business practices to acquire land more efficiently, and improve crop yields, customer relationships, sales and profitability. Social benefits also are also identified through mobile phone technology adoption.

Originality

This study reports on how Ghanaian farmers working in remote, rural settings employ mobile phone technology to improve their business practices. Its findings are set within the Technology-Organization-Environment (TOE) framework to highlight the benefits associated with adopting digitalization in an African country heavily reliant upon its agricultural sector.

Keywords:

Developing countries; small firms; technology.

Introduction

Digitalization has accelerated significantly during the past 20 years, transforming the behaviours, operations, and communication methods of individuals, consumers, and enterprises worldwide. This phenomenon is ascribed to the emergence of Information and Communication Technologies (ICT), including internet and mobile phone technologies, which generate novel products and processes, new market channels, alongside technological progress. ICT and its attendant benefits are posited as a crucial driver of wealth. For nations to leverage economic engines, they must effectively employ ICT (Myovella *et al.*, 2020).

Digitalization is essential for promoting economic success in both developed and developing nations (Arendt, 2015). For example, there is evidence to indicate that enhancements in telecommunications infrastructure contribute to economic growth (Mungadi and Argungu, 2024). Nonetheless, its impact may be contingent upon a nation's degree of development (Arthur *et al.*, 2024). It is suggested that the swift expansion of broadband infrastructure impacts lower-income nations more significantly than high-income countries (Awad, 2024), although the picture is not clear cut. Lee and Kang (2024) for example, note that investments in ICT yield greater economic advantages for developed nations compared to developing ones, particularly in African countries. Nonetheless, various scholars (Arendt, 2015; Dossou and Berhe, 2024) assert that lower-income nations are converging with high-income nations through leapfrogging effects facilitated by ICT use.

The application of digital tools and systems to support agricultural practices and procedures is referred to as digitalization of agriculture (Abbasi *et al.*, 2022). New tools are being incorporated into farming systems as a result of the growing accessibility of mobile phones, the internet, and emerging technologies such as big data analytics, artificial intelligence (AI) and machine learning (Sulimin *et al.*, 2019). Farmers' access to - and use of - various digital tools, software, and services for farming activities is one way that

digitalization is evident in Africa’s smallholder systems (Izuogu *et al.*, 2023). Simple digital equipment such as phones, computers and tablets, can be used directly or indirectly as part of digitalization (Gabriel and Gandorfer, 2023). Digital equipment is also used for leveraging data to provide products and services that improve agri-food procedures (Izuogu *et al.*, 2023).

This aim of this paper is to identify the benefits of mobile phone technology adoption to rural farmers in the remote Kwahu district of Ghana and to explore how they have improved their small business agricultural practices. Its objective is to draw upon rural farmers’ personal experiences of using mobile phones, the benefits they have experienced in the deployment of this technology and the improvements they have made to their agricultural practices through using this technology by means of in-depth face-to-face interviews.

The study is set within Tornatzky *et al.*’s (1990) Technology-Organization-Environment (TOE) framework which highlights the benefits associated with adopting digitalization to understand how the farming business practices of rural farmers in Ghana improve when they employ mobile phone technology.

Literature Review

Technology-Organization-Environment (TOE) framework

The Technology-Organization-Environment (TOE) framework is a theoretical construct in information systems proposed by Tornatzky *et al.* (1990). This model sets out how the adoption and utilisation of new technologies are affected by multiple factors, encompassing the attributes of the technology, the organisational context, and the external environment in which the organisation functions (San-Martín *et al.*, 2016).

The Technology context relies on the availability and characteristics of existing and new technologies which allow organisations to innovate their business practices. It encompasses numerous internal and external aspects that can enhance organisational

productivity including compatibility, complexity, and perceived relative advantage (Bin Naeem *et al.*, 2024).

The Organization context relates to the systems structure, scope, human resources, financial strength, and experience in adopting technology. In essence, it includes factors such as business size, available resources, and managerial support, i.e. resources that facilitate the technology adoption process within the organisation. The Organization context is fundamental to enhancing quality in the services and products being offered (Addy *et al.*, 2024).

The Environment context refers to macro-factors in the organisation's operating environment that affect its capacity to gain external resources. These include its industry sector/markets, the nature of competition, regulations and government contacts. These factors can influence cost reduction (Bin Naeem *et al.*, 2024).

The TOE framework has been used extensively in research concerning technology adoption and implementation within organisations (Addy *et al.*, 2024) and as a means of comprehending the intricate interactions among these three contexts (Februadi *et al.*, 2025). The literature reports TOE as being an appropriate frame to examine the importance of digitalizing agriculture and enhancing farming business practices in developed nations such as Italy (Giampietri and Trestini, 2020) and more widely across Europe (Penone *et al.*, 2024), in newly industrialised nations such as China (Li *et al.*, 2024) and in developing economies (Naatu *et al.*, 2024). For example, the TOE framework has guided research which has identified key determinants of the success of ICT adoption in Somalian agribusinesses (Abdullahi *et al.*, 2021). The TOE framework has also been used to frame research in small and medium sized enterprises (SMEs) in the agricultural sector (Nagy *et al.*, 2025). Our research focuses on small farming business entrepreneurs in rural Ghana, taking forward the use of this model into a remote agricultural region of Ghana.

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Mobile phone technology use and its relevance to agriculture in sub-Saharan Africa

While considered a necessity in Western economies, the use of mobile phone technology remains less prevalent, although it is becoming a growing business resource, in developing economies (Konte and Tetteh, 2023). Mobile phones provide a flexible tool for streamlining corporate procedures and are crucial in bridging the divide between urban and rural areas in increasingly industrialising nations (Agrawal and Narain, 2023; Kamal and Bablu, 2023). In places without landline telephone systems or other communications infrastructure, mobile phones are crucial (Adam, 2023).

Sub-Saharan Africa has some of the lowest levels of infrastructure investment in the world. Only 29% of roads are paved, and barely a quarter of the population has access to electricity. There are fewer than three telephone landlines available per 100 people. Mobile phone technology use has expanded more rapidly here in the last 20 years than in industrialised nations, where robust telecommunications infrastructures have been established for many years (Kouladoun, 2023).

In 2021, sub-Saharan Africa had 515 million mobile services subscribers, accounting for approximately 46% of the population. Recent estimates indicate that 40% of the adult population utilises mobile internet, whereas 44% reside in locations with mobile network coverage but do not engage in mobile internet services (Odhiambo, 2022). Mobile phone technology use in Africa is not consistent across the continent. For instance, the use of mobile money (MOMO) services is highest in Kenya with 85% of the population using them. This compares with 55% of the population in Ghana, 45% in Tanzania, and 8% in South Africa and 4% in Nigeria (Beyene *et al.*, 2024). Despite this inconsistent coverage, a beneficial relationship has been identified between MOMO services and financial inclusion, welfare, and several developmental outcomes in sub-Saharan Africa (Zreik *et al.*, 2024).

In sub-Saharan Africa, technology use in agriculture has advanced significantly in the last two to three decades. Technology has improved and scaled up innovations driven by the use of Global Positioning Systems (GPS), Internet of Things (IoT), cloud data storage, AI, gene editing, and big data in cementing a fourth agricultural revolution. Digital technologies are used to manage agricultural production and monitor production variables based on scientific datasets. Food crop development, animal rearing and processing, and reduced production costs and waste all flow from employing just required inputs, helping to generate more sustainable agriculture (Kouladoun *et al.*, 2022). The digitalization of agriculture effectively addresses agricultural value chain uncertainty.

Mobile telephony has introduced new opportunities at the individual level as well. Mobile phones facilitate connections among individuals, information, markets, and services across urban-rural and socioeconomic divisions (Elom *et al.*, 2024). For example, in Mali, inhabitants of Timbuktu can contact relatives residing in the capital city of Bamako or those in France. In Niger, day labourers can contact acquaintances in Benin to enquire about job opportunities without incurring the US\$40 travel expense. In Malawi, those impacted by HIV and AIDS receive daily text messages encouraging them to adhere to their medication plan. Citizens in countries such as Kenya, Nigeria, and Mozambique can report significant issues by text messages to a centralised server that is accessible in real time to a global audience (Simatele, 2024).

The case of Ghana

Ghana's economy is one of the most stable and competitive within West Africa, and this has attracted mobile telecommunication companies (Agyeman-Duah, 2019). Deregulation of Ghana's telecommunications took place in 1994 with the Accelerated Development Program (ADP) supported by the World Bank and the International Telecommunications Union came into effect in 2000 (Osei-Owusu, 2015; Sey 2008). The aim was achieve a density of 1.5 and

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2.5 fixed lines per 100 people in rural and urban areas respectively as well as improving mobile services (Arthur and Arthur, 2017). This project was placed under the management of the National Communications Authority and, with government support, the Ghana Telecommunications Company was created to manage this. The fixed line operations were later privatised and the contract awarded to Telecom Malaysia (Avle, 2020; Sey, 2008). As, part of the liberalisation and privatisation program, another consortium called WESTEL acquired a 10% stake to support providing about 300,000 telephone fixed lines to meet the ever-increasing demand due to the opening up of the economy. The gap between telecommunications availability in rural and urban areas should have narrowed through the increase in the number of telephone lines (Nimako *et al.*, 2012; Overå, 2008). However, installation costs of up to \$200 per fixed land line and changes in government meant that the objectives of the ADP did not materialise. In addition, Ghanaians felt that land line infrastructural facilities were the responsibility of the government and were not prepared to pay for these services. The belief in personal ownership has contributed to the uptake in mobile phone possession (Williams and Kwofie, 2022). The reduction in the cost of bandwidth has encouraged people and businesses to use the internet through the private mobile telephony operators (Mungadi and Argungu, 2024). Ghana's mobile telephony companies are AirtelTigo, Capital Telecom, Globacom, MTN Ghana, and Telecel Group (Afutu-Kotey and Gough, 2022; Lusha, 2025).

Turning to the agriculture sector in Ghana, it is notable that this accounts for around one-fifth of the country's GDP (Kwakwa *et al.*, 2023) and around 4% of export earnings (FAO, 2023). It provides employment to about 45% of the population living in rural areas where businesses focus on farming, fishing, and agro-based processing, and makes a substantial contribution to the nation's economic expansion through tax contributions (Dziwornu *et al.*, 2024). Ghana's agricultural market size is expected to reach USD 3.87

1 billion by 2029 (Mordor Intelligence, 2024). Despite the relevance of this sector to the
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3 economy, growth has stagnated compared to other sectors (Nyamekye *et al.*, 2021). At the
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5 end of 2020, the sector accounted for 18.24% of GDP, down from 25.2% in 2015, and 28.2%
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7 in 2014 (Danso-Abbeam *et al.*, 2021). The reason for this stagnation is that although previous
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9 governments purported to make large investments in the agriculture sector, these did not take
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11 place (Nkansah-Dwamena, 2024). The sector needs the support of both government and
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13 private sector investment if it is to grow and to help reduce unemployment and contribute to
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21 The farming systems used in Ghana are relevant to understanding business practices
22 and the relevance of mobile technology adoption. The land fallowing practice is long-
23 established; it can be short, long-term or annual. During the fallow period, farmers move to
24 another piece of land allocated to them either by family or the community (Goldstein *et al.*,
25 2015). This system is more appropriate for small-scale subsistence farmers than for large-
26 scale farming businesses (Baah and Kidido, 2020). The practice of multi-cropping is a system
27 whereby two or more crops are sown on the same piece of land. Long growth periods are
28 required for some crops such as cocoa and coffee, so to gain a regular income and feed their
29 families, farmers integrate maize, cassava, plantain and banana, according to the planting
30 season. Hence, in multi-cropping, one is usually the main crop and the other is a subsidiary
31 (Owusu-Ansah and Chigbu, 2020).
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46 In addition to multi-cropping, some rural farmers adopt cooperative farming, known
47 as 'Nnobia'. This is a system where farmers in a particular area support each other in the
48 planting and the farming processes to cultivate large farms cost-effectively (Agariga *et al.*,
49 2021). Nowadays mobile phone technology is used to coordinate this process, enabling
50 farmers to know which farms need their support in planting or land clearing. Cooperative
51 farming helps engender community spirit and improves social networks (Owusu-Ansah and
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Chigbu, 2020). With the ‘Abunu and Abusa’ practice, the landowner allocates land to the farmer who then cultivates it, but when the crops are harvested, the produce is divided into two or three parts depending on the agreement made between the landowner and the farmer (Asiama *et al.*, 2021). In the ‘Abunu’ system the farmer takes half of the harvest and the other half goes to the landowner; in the ‘Abusa’ system, the farmer gets two-thirds and one-third goes to the landowner (Baah and Kidido, 2020).

The research study context

In rural areas lacking landline telecommunications and other communications infrastructure, small business owners must use mobile phone technology if they are to grow and improve their business operations. Digitalization is needed to keep pace with economic development but this raises the question as to how those in remote locations, such as farmers who operate small businesses in rural Ghana, adopt, use and deploy mobile phone technology as a digitalization tool, integrating it into their farming practices.

This research was conducted in the Kwahu district in the eastern region of Ghana. The main activities supporting people’s livelihoods here are farming and fishing. About 85% of farmers are small business entrepreneurs (SBEs). By employing farm assistants they contribute to Ghana’s job creation and the country’s GDP (Alhassan and Owusu, 2023). However, access to markets and customers is a fundamental challenge to SBEs in this area given its mountainous terrain and the Volta Lake. Reliable transportation and good telecommunication infrastructure, which support market access, are major problems; hence the need for Kwahu farmers to adopt mobile phone technology to connect to the rest of the world (Acheampong *et al.*, 2023).

In this study we apply Tornatzky *et al.*’s (1990) TOE model, bringing together the technological, organisational and environmental factors that have framed Ghanaian rural farmers’ digitalization of agriculture. We analyse the benefits that farmers have experienced

and the changes they have made to their farming business practices as a result of their adoption and use of mobile phone technology. The research questions are:

RQ1: What do farmers in the remote Kwahu region of rural Ghana report as the benefits of adopting mobile phone technology to their small business operations?

RQ2: What improvements have farmers in the Kwahu region made to their farming business practices as a result of using mobile phone technology?

Methodology

The Kwahu region is particularly remote and geographically difficult to reach. The northern part of the district comprises islands lying within the River Afram, accessible only by boat or canoe. The area is also dangerous (with robberies commonplace and venomous snakes posing a threat to the unwary). Being so remote and lacking landline telephony, the Kwahu district presents a clear opportunity to assess the benefits of adopting mobile phone technology and to find out how this can result in improvements to farming business practices. The region was also chosen because, despite being rich for research purposes, it remains **under studied**. As well as the location posing a risk to researchers trying to access it, its people are private and secretive, and reluctant to engage with public officials or foreigners. This is in part due to their cultural and religious beliefs but also due to their desire to avoid government taxation officials contacting them and such officials are not given access. Negotiating access requires discussion with community leaders and chiefs. Research here was possible because the researcher is a native, fluent in the local language and has family ties in the district.

Farmers in the Kwahu district can choose to be represented by one of two farming groups or work alone with no support. Unrepresented farmers are known as peasant farmers.

One **farming group** is operated by the Ministry of Food and Agriculture (MOFA), a governmental organisation. MOFA is responsible for the development and growth of agriculture in Ghana. It formulates policies to aid the agricultural sector and supports the

implementation of these policies via its extension arm. Farmers who register with MOFA can access the support it provides through agricultural services delivered via its extension officers. The Ministry also monitors agricultural projects and programmes to ensure their success. Even though this is a government agency, farmers are not obliged to register; they can choose to work with the other agency if they wish. [Further information can be obtained from www.mofa.gov.gh.]

The second farming group is a non-governmental organisation called ESOKO (with the acronym originating from the Swahili name Soko, which means market and 'e' representing 'electronic'). This is a private initiative built and supported with funds from international donors like the Food and Agricultural Organization (FAO). Like MOFA, ESOKO registers farmers and provides them with agricultural support in areas of agronomy, pricing, planting, and other services using mobile phone technology. ESOKO's main aim is to provide an agricultural profiling and messaging service to farmers who have registered with it. [Further information can be obtained from www.esoko.com.]

The farmers in this study were either part of the MOFA or the ESOKO farming groups. Rather than conduct research among unrepresented peasant farmers, these two farming groups were approached as they represent the majority of farmers in the region and because these groups are key to generating revenue, supporting employment and have the greatest potential for boosting Ghana's export performance (Adams, 2017). Both groups provide agricultural advice to farmers in exchange for farming data. The ESOKO officers additionally provide some training on mobile phone technology use to enable farmers to access information sent to them on weather, pricing, and other farming advice.

The research process

The researcher made face-to-face appointments with the executive officers responsible for agricultural activities in the Accra offices of MOFA and ESOKO. At these meetings the aims

and objectives of the research were explained and the request was made for the executive officers to contact farming members on the researcher's behalf. This was agreed and the executive officers asked their membership to respond indicating willingness to participate in the project. In total, 55 farmers showed interest in taking part (22 from MOFA and 23 from ESOKO). The executive officers then arranged for individual face-to-face meetings to take place at their respective local Kwahu district offices with all 55 farmers so that they could meet the researcher, discuss the project and the terms of their participation. It was explained that participation would be anonymous and each farmer was given a consent form to take away while they considered whether they wished to go ahead.

The researcher followed up the face-to-face meetings by calling each farmer after they had time to consider the proposal carefully to arrange for interview research to be conducted on each farmer's farm. Of the 55 names originally supplied by MOFA and ESOKO, 30 decided not to go ahead at this stage, leaving 25 farmers who agreed to participate. Of these, 12 were from MOFA and 13 from ESOKO although subsequently one of the ESOKO farmers withdrew for personal reasons. The researcher booked appointments to visit all 24 farmers in person to conduct the research and at this time the consent forms were collected and subsequently stored safely. The data were collected in the period between 2019 and 2020.

Participant profile

The range of participants demonstrates heterogeneity in terms of age, gender, educational background, farm size, number of employees, agricultural produce, and number of mobile phones used (Table 1).

TABLE 1 here

The farmers ranged in age from 33 to 76, with an average age of 50. Only four of the farmers were female; this is because within the Kwahu area farming is seen as a man's business and male farmers are viewed as entrepreneurs. In contrast, women are viewed as peasant farmers,

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conducting their work as part of home management (Azumah *et al.*, 2023). Ten farmers had no formal education, four were educated to primary school level, seven to secondary school level and three held university degrees. Farm sizes ranged from five to 60 acres, averaging 33 acres. The majority of the farmers employed fewer than 10 people; only five had 10 or more employees. The farmers employed a total of 151 people, averaging around six employees per farming business. All of the farmers grew crops (predominantly maize and yams); in addition two raised poultry, two had piggeries, two raised cattle, and one was involved in beekeeping. One farmer made use of three mobile phones, 17 had two mobile phones and six used only one.

Data collection and analysis

The research study used a qualitative approach with semi-structured in-depth interviews. This approach enabled the use of open questions to explore farmers’ feelings, thoughts, and experiences of using mobile phone technology and its potential benefits as a digitalization tool. It also enabled the researcher who conducted the interviews in Ghana to follow up areas in depth and order the questions aligned to the flow of the conversation. Interview questions were aligned with the two research questions (Table 2).

TABLE 2 here

Interviews averaged 50 minutes ranging from (45 to 90 minutes). The interviews were audio-recorded with the farmers’ explicit agreement. The interview data were transcribed by the interviewer (a total word count of approximately 50,000 words) and saved in a Microsoft Word document prior to being imported into the qualitative analysis software tool NVivo 12. This process facilitated the interviewer in acquiring a thorough comprehension of the issues discussed on location in Ghana prior to a thematic analysis being conducted. Thematic analysis provides a method for systematically examining data and analysing patterns emerging from it (Braun and Clarke, 2006).

Using NVivo, the interviewer highlighted the transcripts such that the quotes were categorised under thematic nodes which were given short code titles. These were then shared with the UK-based second author and agreed via a process of discussion. The first round of coding identified some issues of overlap such that some of the nodes were redundant. In the second coding round, overlapping nodes were merged and those that were redundant were removed. Again, an iterative process of discussion took place to agree on any coding redundancy. As Saldaña (2021) notes, care was taken to ensure that in the process of reducing redundancy and streamlining the data, valuable nodes were not lost. The finalised labelled nodes were aligned with the two research questions and were given definitions which were mutually agreed by the two authors (Table 3). As shown in Table 3, the ESOKO farmers who had received some training on mobile phone use by their local agronomists perceived additional benefits from adopting the technology than did the less experienced MOFA farmers. Hence, additional nodes (code titles) are included and defined for the ESOKO farmers.

The text quotes were tabulated relating to each code title by the interviewer such that representative quotations could be easily identified for illustrative purposes within the findings. Both authors then re-read the quotations to ensure correct classification of the quotes. The number of sources (S) who cited issues under each coding theme, with the volume of references (R) they made to them, were noted so that the importance of each could be determined, thereby guiding the presentation of quotations used within the findings. These counts are presented for each theme in Table 3. The authors then discussed the nature of the definition of each coding theme and determined how this fitted within the TOE framework (Tornatzky *et al.*, 1990), shading each theme and definition under Technology, Organization or Environment as appropriate.

TABLE 3 here

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Findings

The research findings are presented aligned with the research questions and coding themes in Table 3. For each theme, the link to Tornatzky *et al.*'s (1990) TOE framework is presented. Representative quotations from the interview transcripts are given as examples. For each coding theme, the number of sources (S) and references made (R) are given to demonstrate the level of importance placed on each issue.

RQ1: Benefits of using mobile phone technology

Improved customer benefits

This section reports on the findings in relation to: customer access (18S, 20R); relationship building (11S, 14R); marketing and sales (12S, 15R); and social media (6S, 8R). These issues all fall within the Technology context of the TOE framework.

The findings underscored the criticality of mobile phone technology serving as a pivotal element in coordinating access to customers. Due to the topography of the Kwahu lands, there was no access to landline telephone facilities and therefore the farmers had no alternative than to rely on the use of mobile phone technology:

“How could we have connected to the rest of the world if there were no mobile phones? Look at the roads, look at the mountains, when it rains, who wants to come here?” (#6)

The farmers expressed concerns about storage and transportation issues, which resulted in deterioration of a significant portion of their crops if these could not be sold. They reported instances when they were compelled to distribute surplus food items without charge, such as yams, plantains, maize, and avocados, as it was not feasible for them to transport these items back to their villages. Nevertheless, with the assistance of mobile phones, they were able to avoid this problem: customers enquired about the availability of produce,

provided specifications and quantities and completed financial transactions through mobile phone technology, prior to market days, resulting in guarantees of sales:

“Before the buyers come, they use the mobile to do orders and pay. I load the truck and it goes to deliver. Now a lot of our produce don’t get rotten! You see, the phone does the business.” (#3)

They also reported that by personalising ring tones, this led to improved customer relationships and segmentation in terms of communications:

“Most of my customers have specific ring tones which I have assigned to them, making communication with me easier and knowing exactly what to say at what time. For example, for my customers in Mame-Krobo in Afram Plains, so anytime they call, I know that it is my customers who are calling me for supplies or otherwise.” (#12)

The ESOKO farmers also spoke about some of the benefits that had resulted from training in mobile phone technology, including using their mobile phones to build relationships through regular sharing and exchange of information via calls and messages, rather than travelling to meet their business contacts in person:

“The mobile phone allows me to keep good relationships with customers. When I call we talk about anything not always business. I am interested in their activities more than the business I do with them.” (#16)

In addition, they reported on the benefits of using WhatsApp for the exchange of marketing, pricing and customer information. This provided an instant communication tool which they relied upon. For example, farmers contacted their colleagues and connections in the cities for information on fertilizers and current pricing information for maize and yams. In this way they kept abreast of current information and said that this prevented customers cheating them by offering to buy their produce at lower than market prices.

The ESOKO farmers also indicated that by using WhatsApp and other social media platforms they were able to develop networks that benefited their farming businesses by developing friendships and sharing farming information:

“I am on three WhatsApp platforms with farmers in Kwahu, Kumasi and Brong Ahafo. Sometimes they tell us about shortages, and we supply quick to these new markets. Business is good when this happens.” (#15)

The ESOKO farmers achieved further benefits through linking up with their agronomists using social networks, thereby benefitting from extra training and support. In addition, with the agronomists’ support, new markets and customers were secured. In turn, this led to further marketing and customer access opportunities through the sharing of business information on the farmers’ Facebook and other social media platforms. This attracted enquiries which sometimes resulted in new customer acquisitions. Finally, the ESOKO farmers commented on the advantage that mobile phones provided through pictures and videos in supporting their marketing activities:

“Using WhatsApp technology with the support of our ESOKO officers has helped us a lot. We send photos, videos, and describe what is happening on the farms. These videos help sell our products when we put it on our WhatsApp”. (#20)

Agricultural benefits

This section reports on the findings in relation to access to agricultural information (20S, 24R) and farming advice (18S, 22R) which fall under the Environment context of the TOE framework. It also addresses digitalization knowledge (8S, 9R) which is part of the TOE Organization context.

The farmers agreed that information on agricultural inputs and access to advice were central to farming success. Agricultural inputs ranged from machinery to seedlings and

fertilizers, insecticides and weed killers. These information inputs were either government-supplied through MOFA or from companies in the private sector. As transportation infrastructure issues made it impossible for the MOFA and ESOKO extension facilitators to deliver these inputs in person, mobile phone technology has become the conduit for quick transfer of information. The findings also indicated that the farmers used the phone to access price indexes and variation information which were sent to them monthly so that they could remain up-to-date on pricing fluctuations.

Rural farmers are heavily dependent upon access to regular weather information to prepare for the planting season. The MOFA and ESOKO farmers indicated that mobile phone technology helped them with access to this. Farmers also used it to receive weather information from friends, extension officers and agronomists, as well as call centre staff.

The findings indicated that mobile technology was also used as a conduit to discuss pest control between the agronomists and the MOFA and ESOKO farmers:

“When we have problems of fall army worms eating our maize leaves and destroying them, I use my phone to take pictures. Sometimes they require video. We do and send them. They call and advise us. This helps us to apply the pesticides.” (#8)

Such regular communication between the farmers and the officers meant that the farmers felt close to them even without being able to see them face-to-face via visits to their farms. Thus, although mobile phone usage has limited agricultural officers travelling to visit the farms, farmers received regular advice when needed.

Farmers were asked about their opinions on digitalization through mobile phone technology. The ESOKO farmers had a far better understanding of digitalization as a business improvement tool than did the MOFA farmers **due to the training they had received**. Eight ESOKO farmers indicated that using mobile phone technology helped them with multiple

interconnected aspects of the farming process, from the acquisition of the land, preparation and clearing, planting, and managing the farm through to harvesting and marketing:

“I could not have done any aspect of my business should the mobile phone not been available. Calling farming assistants, I use the phone, paying them, I use the phone. Contacting customers and suppliers, I use the phone. Digitalization is a big word but means everything I do on my farm using the mobile phone.” (#14)

Financial benefits

This section reports on the findings in relation to MOMO and banking (18S, 25R), and loans and insurance (11S, 15R). These issues fall under the Organization context in the TOE framework.

The findings indicated that MTN Ghana, Telecel Group and Airtel-Tigo were the most popular telephony companies, and that they were the ones upon which the farmers conducted their mobile banking, savings services and insurance activities. Seventeen of the MOFA and ESOKO farmers were unbanked, meaning that they did not possess formal bank accounts; instead they had mobile wallets to conduct mobile banking:

“The mobile phone is my bank account. I am able to check how much comes in and I spend too.” (#12)

Even the remaining seven who did have bank accounts said that they did not utilise them because mobile banking and money usage were far more secure, and accessible to them no matter where they were:

“I have a commercial bank account but most of the customers I do business with pay me by phone.” (#2)

The findings further indicated that the mobile phone was the conduit that facilitated the exchange of financial transactions between farmers and customers with the use of

physical cash reducing. This helped to reduce road and market robberies. Despite these benefits, the farmers indicated that they faced constant threats from scammers who pretended to be calling from the telephony companies. If they were not careful and gave out their mobile wallet PIN, believing that the call was genuine, the scammers stole the money in their wallet by transferring it into another account, which the farmer could not trace.

The ESOKO farmers further commented that mobile phone technology, together with its connectivity to networks, facilitated their ability to promptly acquire liquid funds in the form of short-term loans to address unforeseen circumstances. In addition to supporting financial mobilisation, the ESOKO farmers reported that mobile phone network providers enabled them to access health insurance policies designed for the rural farmer by a micro-insurance company as well as medical advice 24 hours a day outside the Government's National Health Insurance Scheme:

"I have a MOMO and Insurance account, and that is what I use. MTN and my Esoko officer recommended that to me. When I signed, they taught me how to use it." (#18)

Farmers reported that they bought these health insurance policies through their mobile phones, paying their premiums through their mobile wallets. Once in place, they received medical advice, as well as health information from doctors via their mobile phones. This mobile health service (m-health) was considered very beneficial as the location of their farms might otherwise deny them - and their families - access to medical facilities.

Family access

Using mobile phone technology allowed farmers to have family access (19S, 20R). This can be seen as an organisational resource, falling under the Organization context of the TOE framework.

Close contact with their families, no matter their location, helped the farmers to gain digital skills. These included the ability to access and save information, and to send and receive messages for example SMS, WhatsApp and MOMO communications, and enabling them to see alerts when these arrived.

“Using the mobile phone allowed me to connect with extended family members in Kwahu, Kumasi and Mame-Krobo ... Because of the mobile phone we are able to solve family issues including exchange of money for family activities where necessary through mobile alert.” (#18)

MOFA and ESOKO farmers indicated that they used their phone for family meetings, connecting with their children both in Ghana and abroad, and provided information to their spouses when needs be. Farmers reported that their children could help them with gaining understanding of how to use their phones, for example to improve their contact with their customers and agricultural officers:

“When it comes to the internet, I have to call my daughter to help me.

Sometimes, when I want to check things like the weather, if my daughter is not there, I have to call my stepson or wait a while.” (#2)

“When I bought my mobile phone, I did not know what to do. It was my son that taught me how to upload my credit and to check the internet. The first time I wanted to send a video to the ESOKO officer, my son assisted me.”

(#17)

Both MOFA and ESOKO farmers also expressed their sense of pride in owning and using a mobile phone. It raised their social standing in the eyes of local people extending benefits beyond agricultural business operations:

“Using the mobile phone makes me feel good. When it is not with me, I feel there is something missing. I can easily contact my wife and the children when I have a problem on the farm.” (#10)

RQ2: Changes and improvements to farming business practices

This section reports on the findings on the farming business process cycle. It addresses land negotiation and acquisition (14S, 17R) explaining the influence of land chiefs (14S, 18R) in these activities. Both of these themes fall under the Environment context of TOE. It also reports on land preparation and seedling purchase (15S, 20R), and planting and farming management (12S, 12R). Both of these fall under the Organization context of TOE. Additionally, for the ESOKO farmers, fertilizer application (10S, 15R), and tackling plant diseases (8S, 9R) (both falling under the Environment context of TOE), and the provision of farming reports (8S, 10R) (under the TOE Technology context) are addressed.

The ‘Abunu and Abusa’ 2/2:1/3 farm share is the most commonly used land acquisition system in the Kwahu district. The ‘Nnobia’ or cooperative farming system is also used. The interviewees had embraced farming as a business and used these land acquisition practices to acquire further lands for expansion. In the past, lessees would have travelled on many occasions to meet the land chiefs and/or the landowners to perform the various rites and traditions. With mobile phone technology, the processes, communications, and first rites (sharing and showing of intent) were all carried out by phone. This had eliminated travel problems and wasted time for landowners and lessees:

“Currently, I have 60 acres. When I was acquiring this land, there was no need to travel there, I spoke to the chiefs on the phone, they discussed the terms with me, I paid the dowry through my MOMO. Then they went to pour their libation and perform the traditional practices. Afterwards there was a formal meeting for the land cutting. That was when I travelled there.

All other payments associated with the lease were discussed on phone.”

(#15)

The next stage within the farming business practice cycle is land clearance and seedling purchase. These activities involve coordination of purchases such as acquiring seedlings, farm boots, and weedicides. Previously, farmers would have had to travel to various places but the use of mobile phone technology solved this coordination problem:

“One time I needed to buy weedicides and corn seedling. On way to Accra, we were accosted by armed robbers who took all our money and even shot our driver. Thank God he was not killed. Today, I do my activities all the time using my phone. I even pay the workers on the phone. This has helped me considering my age.” (#10)

The next stage in the farming business process concerns planting and farming management. The findings indicated that once the planting of the crops began, labour management issues become a difficult issue for farmers. They had to recruit casual farmhands, but this required knowing where to locate them and attract them to their farm to work. This process was aided considerably through the use of mobile phone technology:

“Using the mobile phone has helped me a lot when it comes to getting workers every season. At first, it was difficult but now it is easy as I have stored the numbers of the other workers on my phone. Any time I need them I call.” (#17)

Fertilizer application and plant disease detection are fundamental to farming businesses. The findings indicated that mobile phone technology was used by the ESOKO farmers to access crucial information on these environmental issues. Exchanging information was to the benefit of both the farmers and the agronomists, even taking into account the cost of data/air time for phone use:

“The fertilizer usage and availability is in my pocket. With my phone, I can go on the internet to compare prices, I can also place orders, and I can also call the ESOKO officers and ask them how to apply them.” (#15)

“Last year, five acres of my farm was affected by the Maize Streak Virus. Look at where we are in the Afram Plains with bad roads. How many agricultural officers will travel here? With the mobile phone, they communicated with us both on audio and on video. They got a clear picture of what is happening. They advised us on video how to apply the herbicides. Within two weeks of spraying, I could see the leaves of the maize getting greener again.” (#19)

Discussion

Benefits of mobile phone technology adoption

With regard to the key benefits of using mobile phone technology for digitalizing agriculture, the study found that farmers used mobile phones as a resource to access payments from customers through MOMO, raise short-term loans, and mobilise finance using mobile banking facilities. Farmers were supported by telephony companies to upload software allowing them to send and receive money from customers, friends and family, and from their banks if they had bank accounts. Farmers who did not hold traditional bank accounts relied solely on the use of mobile banking via their phones. The technology also eliminated handling physical cash, which farmers and customers used to have to carry during business transactions and on market days, exposing them to targeting by armed robbers on their journeys. These findings extend the views of Konte and Tetteh (2023) on mobile phone usage by medium and small-scale businesses into the remote farming context of rural Ghana.

Farmers with access to MOMO services were encouraged by the telephony companies to register for health and farming insurance policies connected to their mobile wallet. Health insurance policies enhanced farmers' access to medical advice. Farmers saw such policies as

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very helpful to support their health and that of their family members. This finding extends the views of Kamal and Bablu (2023) on the value of mobile phone-enabled services and applications into the Ghanaian rural farming context.

Using mobile phone technology enabled farmers to connect with their families while out on their farms. Farmers could resolve issues regarding payments with customers, suppliers and farming assistants without having to travel. They could also learn with help from their children. Thus, the mobile phone acted as a bridging tool allowing contact with both close and extended family groups as well as business contacts (Agwu, 2021; Dar *et al.*, 2018).

On agricultural benefits, the study indicated that using mobile phone technology enabled the farmers to access, receive and distribute information among themselves as well as with institutions such as the MOFA and ESOKO farming groups, including weather conditions, pricing, fertilizer input access, agricultural machinery and availability of agrochemicals.

Farming business practice improvements

The study’s findings on land use practices are consistent with the literature on farming in Ghana including land fallowing, multi-cropping, cooperative farming, family farming, and the Abunu and Abusa farming systems (Owusu-Ansah and Chigbu, 2020). Notwithstanding this, they contribute to our understanding in that by using mobile phone technology the ease of land acquisition for farming was facilitated no matter the process used.

This study found that the technology provided a communication tool aiding negotiations, and reduced the travel costs and time for both farmers and landowners. Throughout the farming process beginning with land cultivation, the planting of the crops, fertilizer application and disease control, and farming maintenance through to harvesting, the mobile phone facilitated all operations.

Using the mobile phone over time allowed farmers to develop improved customer relationships. By using data stored on their phones (names, addresses and supply orders) farmers could plan how to manage their customers more effectively. Farmers were also able to develop credit and payment terms relationships with their customers based on the orders they received. Farmers were able to provide customised services, for instance through the use of specific ring tones. These meant that farmers knew who was calling them and could respond with personal greetings, information and knowledge of their business. Although this personalisation of ring tones is a basic function, it illustrates that mobile telephony does not need to deliver complex business solutions to be useful. In this example, personal and sustainable relationships were enhanced leading to identified competitive advantages. Through interactive and swift information exchange with customers and suppliers, for instance when there were shortages of products in a market which other farmers were unaware of, farmers identified advantageous marketing opportunities.

With regard to socio-cultural factors, the findings indicated that social and cultural peer influences in the local farming environment influenced the adoption of mobile phone technology. Tribal and community support was important in the adoption process. A 'feel-good factor' linked with a sense of belonging and increased confidence was in evidence once farmers had adopted the technology and they had connected well within their community through its usage. Although some farmers indicated that using the technology reduced face-to-face contact, this was outweighed by the positive benefits of being able to stay connected with the rest of the farming community and customers no matter the farmers' physical location.

Theoretical implications

Tornatzky *et al.*'s (1990) TOE framework offers a helpful perspective on the digitalization of agriculture in rural Ghana through mobile phone technology. The findings of this study

indicate that both MOFA and ESOKO farmers benefitted under the Technology context of this framework as evidenced by improved customer access as a direct result of adopting and using their mobile phones. A notable point that emerged from the research was that the ESOKO farmers, who had received some training in mobile phone use from their ESOKO officers and telephony companies, reported additional technological benefits related to marketing and sales, social media use, and relationship building with customers and suppliers. The Technology context was also evident in ESOKO farmers' use of the mobile phone to improve their business practices through the exchange of information with agricultural officers and making use of data in farming reports. **These findings indicate that the provision of training in the use of mobile phone technology has the potential to create a range of technological benefits resulting in improved practices with subsequent business benefits. It suggests that training is very important for rural farmers if the Technology context is to give them the additional organisational productivity and competitive advantage suggested in the literature (Bin Naeem *et al.*, 2024).**

The findings also show that both farming groups experienced organisational benefits by adopting and using mobile technology. The Organization context of the TOE model was evident in the identification of human resource and financial benefits. Both MOFA and ESOKO farmers reported benefits from easy family access enabling them to communicate and take advice from distant family members as well as financial benefits through the use of **MOMO** and banking. The Organization context was also evident in improved farming practices for both farming groups, particularly in land preparation, seedling purchase, planting and farm and labour management. However, it is notable that the ESOKO farmers experienced further business improvement organisational benefits through their greater digitalization knowledge. This group also had improved access to financial services as a result of their use of mobile phone technology, **resulting in greater financial strength. Again,**

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3 this demonstrates that if enhanced quality in products and services are to be offered, as
4 suggested in the literature (Addy *et al.*, 2024), training is crucial.
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8 Finally, with respect to the Environment context, both farming groups benefitted from
9 access to agricultural information and farming advice, and farmers in both groups also
10 reported changes to their business practices in respect of land negotiation and acquisition
11 with the mobile phone smoothing and speeding up the process of dealing with land chiefs.
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13 Once again though, the ESOKO farmers reported additional issues, namely improvements to
14 their business practices in environmental issues such as fertilizer application and managing
15 plant diseases. This indicates that training in the use of mobile phone technology is important
16 to maximise the Environment context of the TOE model. Understanding fertiliser application
17 and plant disease detection and control improves yields and, as the literature indicates, can
18 influence cost reduction (Bin Naeem *et al.*, 2024).
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31 The application of the TOE framework assists us in our understanding of the benefits
32 reported through mobile phone adoption and use, and in how mobile technology has led to
33 changes and improvements in rural Ghanaian farmers' business practices, aligning with
34 Naatu *et al.*'s (2024) view of it being an appropriate frame to understand digitalizing
35 agriculture in developing economies. A key implication flowing from the application of the
36 TOE framework in this study is the identification of the importance of training and thereby
37 gaining digital skills to reap additional technological, organisational and environmental
38 benefits from mobile phone technology adoption and use in the rural Ghanaian agricultural
39 context. Digital technology and the skills to use this effectively can result in higher levels of
40 financial development and inclusive growth potentially leading to uplifting of social and
41 economic hurdles (Kouladoun *et al.*, 2022). This study suggests that digital skills
42 development has the potential to improve both the economic and social lives of farmers in the
43 remote Kwahu region of Ghana if they are able to access support to improve their
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understanding of the attributes and functions that mobile phone technology allows them such that they can enhance their farming business practices.

Implications for practice

This study indicates that digital skills training can make a difference to farming outcomes and it is recommended that governmental bodies and telephony firms provide such training to rural farmers going forward. Telecommunications companies should take steps to highlight financial, social and agricultural benefits of mobile phone usage in rural Ghana. While this could increase telecommunication firms’ penetration of hitherto untapped markets, thereby increasing sales, market share and company profitability, it also can be seen as providing more philanthropic outcomes by facilitating social and community benefits through improving farming businesses in rural communities. It is also recommended that the government works towards policy development to protect farmers in using mobile phone technology through cyber security and data protection laws and use tax incentives to help lower the price of mobile data further.

Although the Ghanaian government has taken steps to improve computer literacy (Mungadi and Argungu, 2024), it has a poor track record in supporting both mobile phone technology adoption (Dzansi *et al.*, 2022) and the agriculture sector (Nkansah-Dwamena, 2024). In addition, telephony companies’ interventions are most likely to be focussed on their own sales and market expansion (Kwabena-Adade and Yeboah-Boateng, 2023). As such, these recommendations are unlikely to be adopted. On a more positive note, however, the family (particularly those of the younger generations), can play a key role in supporting farmers to gain the necessary digital skills to improve their farming business practices and take forward the digitalization of agriculture in remote regions of rural Ghana.

Limitations and further research

This research used a small-scale, cross-sectional, qualitative approach, based upon 24 farmers, 12 each from ESOKO and MOFA, the two groups which represent farming SBEs i.e. 85% of farmers (Alhassan and Owusu, 2023). While our approach was representative of the population that we intended to analyse, namely SBEs in the Kwahu district, and all farming group members were offered the opportunity to participate in the research, we acknowledge that we did not approach all farmers in the region as we did not include unrepresented peasant farmers in our research. Further research is necessary with larger samples and in other rural Ghanaian locations. Research could be expanded into larger business operations to identify other factors that potentially impact upon the digitalization of agriculture and the improvement of farming business practices through the use of mobile phone technology. Research could also be conducted amongst farmers who are not part of a farming group. Longitudinal studies could also help to improve our understanding of the value of mobile phone technology in the agricultural sector. Further research should also address the role of the family in supporting rural farmers in remote regions to gain a greater understanding of - and competence in - using mobile phone technology. Given the value of training identified in this study, further research could usefully explore how farmers learn to use mobile phone technology with a focus on how specific training interventions support their learning activities.

Our research was based on a small sample of rural SBEs using low-tech tools to digitalize their farming businesses. The findings may not be generalizable to enable comparisons to be made to farming businesses using more high-end digital technologies in Ghana or indeed in other countries. Nonetheless, further research that sets out to compare the contributions of specific digital agricultural tools within Ghana and across other Sub-Saharan countries would be a valuable research contribution.

Concluding remarks

Agriculture is a crucial sector in the Ghanaian economy. Agricultural digitalization improves manual workflows and agricultural processes for Ghanaian rural farmers through the use of mobile phone technology resulting in financial, socio-cultural and market opportunities.

Farmers could potentially improve their business practices further through a greater understanding of mobile phone technology linked to their farming activities. Practical action by the government and telecommunications firms, **including training**, could help farmers to improve agricultural productivity in developing economies. The family's role in helping farmers to improve their understanding and use of mobile phone technology is likely to play an important part in the digitalization of agriculture in rural Ghana.

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Table 1: Participant profile

Participant number	Farming group	Age	Gender	Education	Farm size (acres)	Number of employees	Agricultural produce	Number of phones used
#1	MOFA	55	Male	Secondary	30	8	Peanuts, onions, sweet chilli	2
#2	MOFA	62	Male	Primary	30	6	Maize, poultry	2
#3	MOFA	58	Male	Secondary	30	5	Cocoa, avocado, maize, poultry	3
#4	MOFA	35	Male	University degree	15	3	Maize, ginger	1
#5	MOFA	53	Male	None	60	10	Maize, peanuts	2
#6	MOFA	48	Male	None	50	9	Maize, yams	1
#7	MOFA	47	Male	Secondary	43	9	Maize, yams	2
#8	MOFA	37	Male	University degree	10	2	Piggery, maize, cassava	2
#9	MOFA	35	Male	University degree	5	2	Piggery, maize, cassava	2
#10	MOFA	63	Male	None	5	2	Maize, cassava, plantain	1
#11	MOFA	62	Male	None	10	4	Tigernut, cassava	1
#12	MOFA	58	Male	Secondary	40	10	Maize, peanuts, onions	2
#13	ESOKO	35	Male	Primary	35	7	Maize, yams	2
#14	ESOKO	33	Male	Secondary	50	11	Maize, yams	2
#15	ESOKO	70	Male	Secondary	60	12	Maize, oranges, cattle	2
#16	ESOKO	42	Female	None	43	8	Maize, yams	2
#17	ESOKO	51	Male	Primary	55	10	Maize, yams	2
#18	ESOKO	39	Female	None	45	6	Maize, yams	1
#19	ESOKO	49	Male	None	27	5	Maize and yams	2
#20	ESOKO	52	Male	None	15	2	Plantain, mangoes, avocados	1
#21	ESOKO	43	Female	None	20	4	Maize, yams	2
#22	ESOKO	42	Male	Primary	32	4	Poultry, oranges, cattle	2
#23	ESOKO	76	Male	Secondary	35	7	Cocoa, cola, citrus, beekeeping	2
#24	ESOKO	57	Female	None	40	5	Maize, onions, yams	2

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Table 2: Semi-structured interview questions

Benefits of adopting mobile phone technology

1. Briefly describe the reasons for adopting mobile phone technology and how you use it in farming.
2. What benefits did the adoption of this technology give to your farming business?
3. How have these benefits influenced your farming business practices?
4. How easy or difficult was it to apply the technology to support your farming business?
5. Describe how you managed any challenges in using this technology.

Changes to farming business practices

6. Describe how using mobile phone technology has made a difference to your farming business practices. Which of the farming practices, in particular, has mobile phone technology usage influenced the most?
 7. What are the constraints and/or benefits associated with any changes to the management of farming business practices using mobile phone technology? Describe how you manage these.
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Table 3: Coding themes and definitions classified under the TOE framework

Farming group	Identified benefits	Changes/improvements to farming practices
MOFA & ESOKO	Access to agricultural information (20S, 24R): Access to data to assist with purchases/sales and weather information	Influence of land chiefs (14S, 18R): Connecting landowners and lessees and performance of traditional practices
	Customer access (18S, 20R): Regular communication with customers	Land negotiation and acquisition (14S, 17R): Lease negotiations carried out remotely
	Family access (19S, 20R): Regular communication with family members	Land preparation and seedling purchase (15S, 20R): Use of the phone as a search tool to hire/buy equipment/materials
	Farming advice (18S, 22R): Regular communication with agricultural officers/agronomists	Planting and farming management (12S, 12R): Use of the phone to recruit labour and manage production through to harvest
	Mobile money and banking (18S, 25R): Access to finance	
ESOKO additionally	Digitalization knowledge (8S, 9R): Understanding the benefits of the phone as a business improvement tool	Fertilizer application (10S, 15R): Education of farmers by ESOKO officers on use of fertilizers
	Loans and insurance (11S, 15R): Access to financial services for family and business	Provision of farming reports (8S, 10R): The phone as a conduit for information exchange between farmers and ESOKO
	Marketing and sales (12S, 15R): Usage of WhatsApp and other platforms for marketing	Plant diseases (8S, 9R): Early detection of disease through agronomist advice
	Relationship building (11S, 14R): Use of supplier and customer data to assist in relationship management	
	Social media (6S, 8R): Social media content sharing and development	

Key:

S = Number of sources citing each theme

R = Number of references made to each theme

Application of TOE framework (Tornatzky *et al.*, 1990)

	Technology: availability and characteristics of existing and new technologies which allow organisations to innovate their business practices
	Organization: systems structure, scope, human resources, financial strength, and experience in adopting technology
	Environment: the organisation’s operating environment, with macro factors including its industry sector, competitors, and government