Intermediation Capabilities of Information and Communication Technologies (ICTs) in Ghana's Agricultural Extension System

Nyamwaya Munthali
Thesis Supervisor, Postgraduate Studies Department, University of Lusaka
https://orcid.org/0000-0001-9713-3632

Rico Lie
Assistant Professor, Knowledge, Technology and Innovation Group, Wageningen University, The Netherlands
https://orcid.org/0000-0003-4228-5107

Ron van Lammeren
Associate Professor, Laboratory of Geo-Information Science and Remote Sensing, Wageningen University, The Netherlands
https://orcid.org/0000-0002-5062-882X

Annemarie van Paassen
Associate Professor, Knowledge, Technology and Innovation Group, Wageningen University, The Netherlands
https://orcid.org/0000-0001-5341-3114

Richard Asare
Country Representative, International Institute of Tropical Agriculture, Accra
https://orcid.org/0000-0002-5557-9190

Cees Leeuwis
Professor, Knowledge, Technology and Innovation Group, Wageningen University, The Netherlands
https://orcid.org/0000-0003-1146-9413

Abstract

Information and communication technologies (ICTs), specifically those that are digital and interactive, present opportunities for enhanced intermediation between actors in Ghana's agricultural extension system. To understand these opportunities, this study investigates the capabilities of ICTs in support of seven forms of intermediation in the context of agricultural extension: *disseminating (information)*, *retrieving (information)*, *harvesting (information)*, *matching (actors to services)*, *networking (among actors)*, *coordinating (actors)*, and *co-creating (among actors)*. The study identifies the types of ICTs currently functioning in Ghana's agricultural system, and applies a Delphi-inspired research design to determine the consensus and dissensus of researchers, scientists, and practitioners about the potential of these ICTs to support each of the seven intermediation capabilities. The findings reveal that experts reached consensus that interactive voice response (IVR) technologies currently have the highest potential to support *disseminating*, *retrieving*, *harvesting*, and *matching*. Meanwhile, social media messaging (SMM) technologies are currently seen as highly capable of supporting *coordinating* and, to a lesser extent, *co-creating*, but no consensus is reached on the potential of any of the technologies to support *networking*.

Keywords
information and communication technology (ICT), agricultural innovation systems (AIS), ICT for agriculture (ICT4ag), agricultural extension, intermediation, intermediation capabilities, Ghana

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1. Introduction

Agricultural productivity growth in Ghana, necessary to bridge the gap between potential and actual production of food and cash crops, is partly hampered by the prevailing approach to agricultural extension service delivery (Abdulai et al., 2020; Bua et al., 2020; McNamara et al., 2014; MOFA, 2007; World Bank, 2017). This approach is typified by extension largely focused on knowledge and technology transfer to farmers, rather than taking on broader roles (e.g., knowledge brokering, facilitating access to credit, and supporting market linkages) and serving a broader stakeholder base (Agyekumhene et al., 2018; Munthali et al., 2018). The narrow focus of this extension approach is problematic because farmers have multi-faceted production needs, and "improving food production […] is not just a matter of individuals [farmers] receiving messages and adopting the right technologies [from scientists/researchers], but has much more to do with altering interdependencies and coordination between various actors" (Leeuwis, 2004, p. 18).

More specifically, the prevailing extension approach fails to adequately coordinate the set of organisations[2] that support value chain actors[3] in emergent problem-solving (e.g., with respect to climate change impacts), facilitating business linkages between these actors, and facilitating the integration of scientific and other knowledges to produce appropriate knowledge and technology for value chain actors (Abdu-Raheem & Worth, 2016; Asiedu-Darko & Bekoe, 2014; McNamara et al., 2014). These drawbacks in the national extension system hamper production (Msuya & Wambura, 2016; Zwane, 2020).

Since 1996, statements of national agricultural policy objectives in Ghana have consistently posited that reorganisation and improved coordination in the sector are key to agricultural development and climate change adaptation (DAES, 2011; Sigman, 2015; Sova et al., 2014; World Bank, 2017). Based on this policy direction, proposed structural changes in the Ghanaian extension service delivery system have included accommodating private extension organisations to meet the high demand for extension services, value chain-focused interventions, and innovation platforms (Adekunle & Fatunbi, 2014; Agyekumhene et al., 2018; McNamara et al., 2014; Van Paassen et al., 2013). Thus, the extension ideology has broadened, since the 1990s, to include calls not only for top-down, one-size-fits-all approaches (i.e., training and visitation) but also for participatory and bottom-up approaches (e.g., farmer field schools) (DAES, 2011; Davis, 2008). The most recent Ghanaian extension framework is an

2 Research institutions, educational institutions, non-governmental organisations, development organisations, other government institutions, credit providers, weather service providers, transporters, and private extension service providers.

3 Farmers, input suppliers, processors, exporters, traders, retailers, wholesalers, packaging manufacturers, and other manufacturers.

integrated pluralistic extension system (Abdu-Raheem & Worth, 2016; Sigman, 2015). This approach envisages strengthened research–extension linkages, broader service delivery lines, and a larger number of service providers, with the intention of meeting the demand of farmers and other value chain actors for extension services.

Ghana's current extension ideology aligns with the agricultural innovation systems (AIS) perspective. With a view to fostering innovation in agriculture, the AIS perspective focuses on influencing relationships between multiple actors and on the conditions (e.g., policies) that affect the actors' (collective) operations (Klerkx & Leeuwis, 2008; Leeuwis, 2004; Swanson & Rajalahti, 2010). According to the AIS perspective, the focus on multiple actors' relationships is necessary because: (1) innovation occurs when interaction between diverse stakeholders is increased and open, resulting in improved knowledge exchange and access to appropriate knowledge and technology; and (2) innovation requires networking through which actors form partnerships that allow them to access business development opportunities and engage in collective action to respond to systemic challenges holistically (Koutsouris, 2012; Swanson & Rajalahti, 2010; World Bank, 2012).

Extension approaches based on the AIS perspective involve three broad intermediary roles: *demand articulation*, *matching demand and supply*, and *innovation process management*. Demand articulation involves the engagement of sector stakeholders in activities such as joint needs identification, participatory problem diagnosis and assessment, and making interdependencies explicit (Klerkx & Gildemacher, 2012). Matching demand and supply involves establishing sector contacts and developing mutually beneficial relationships—advice, credit, input, and market linkages (Howells, 2006). Lastly, innovation process management comprises the creation of discussion and negotiation space for actors to coordinate and jointly mitigate constraints, maintain relationships, and engage in knowledge-sharing and integration or co-production for continuous innovation (Leeuwis, 2010; Vitos et al., 2013).

Despite Ghana's national agricultural policy direction transitioning to an AIS-based extension approach, barriers still stand in the way of both public and private extension organisations on the path to facilitating this new direction. These factors include financial constraints (e.g., untimely and limited funding), human resource constraints (e.g., freezes in hiring staff, limited staff numbers), and skill set-related constraints (e.g., limited adaptation on the part of educational institutions to develop the facilitation capabilities of extension staff) (MOFA, 2007; Obeng et al., 2019; Sova et al., 2014).

At the same time, Ghana is a key African player in the innovative use of digital information and communication technology (ICT) (GSMA, 2019). Digital ICTs are now central to most spheres of development (Sein et al., 2019; United Nations, 2020), as represented by the ICT for development (ICT4D) discipline, which is focused on "the application of any entity that processes or communicates digital data in order to deliver some part of the international development agenda in a developing country" (Heeks, 2017, p. 10). Among the key ICTs and ICT-enabled services harnessed for developmental purposes are interactive voice response (IVR), short message service (SMS), unstructured supplementary service data (USSD), social media (e.g., WhatsApp, Facebook), and document and data management systems (e.g., Open Data Kit). Such ICTs and ICT-enabled services present new opportunities for connectivity and information sharing to enhance communication-related service delivery (Bell, 2015; Gershon & Bell, 2013). Therefore, these technologies are being explored by scientists, researchers, and development practitioners to respond to the limitations of classical approaches to extension and interaction in Ghana's agricultural system (Cieslik et al., 2018; Fielke et al., 2020; Gakuru et al., 2009; MEST, n.d.; Qiang et al., 2012).

Currently, there is limited literature assessing the capability of different types of ICTs to drive agricultural innovation processes (Fielke et al., 2020; Van Osch & Coursaris, 2013). One such rare study presents an assessment by European experts of the capability of social media and other web-based platforms to act as drivers of agricultural innovation (Hansen et al., 2014). The study finds that a number of the platforms (particularly social media) have high capacity to support the following specific social networking functions that support innovation: discussion (Facebook, NING, ERFALAND, and Yammer); networking (Facebook, LinkedIn, and NING); crowdsourcing (ResearchGate and Crowdsourcing); cooperation (Yammer, ResearchGate, and Wikipedia); and co-production (ResearchGate and Wikipedia). However, the aforementioned European-focused study (Hansen et al., 2014) assesses forms of media that are often not easily accessible in African agricultural contexts, where farmers are typically located in rural settings with limited access to the internet and to mobile devices that support internet services (Aker, 2011; Nyamekye, 2020). Thus, the opportunities for ICTs presented in the Hansen et al. (2014) study cannot be fully leveraged in many African agricultural systems.

In this study we seek to address a research gap through the identification of opportunities for ICTs to support intermediation capabilities relevant to AIS-based extension service delivery, in an African setting—specifically Ghana. The study identifies opportunities through a consensus-building exercise that captures the perspectives of scientists and researchers in the fields of communication, innovation, and development informatics; and practitioners of ICT for agriculture (ICT4Ag).

2. Conceptual context and analytical framework

In this section we start by discussing bridging mechanisms as an overarching concept that incorporates the core concept of this study, which is intermediation capabilities. We highlight the possibility of ICTs functioning as bridging mechanisms and, in doing so, supporting extension organisations in facilitating AIS-based extension service delivery. We also outline the types of intermediation relevant to this facilitation process, and the intermediation capabilities that the ICTs may support. We conclude the section by stating the research questions.

ICTs functioning as bridging mechanisms

Farmers operate in multi-faceted production environments. Enhancing the performance of the Ghanaian agricultural sector, therefore, requires improved information (knowledge) flows among agricultural stakeholders and improved business linkages. The major stakeholders in the agricultural system are knowledge technology providers and users. Their interaction and knowledge exchange need to be enhanced, along with that of other value chain actors who currently only have loose linkages (Adolwa et al., 2017; Asiedu-Darko, 2013; McNamara et al., 2014). The other main actors in the system are bridging organisations that are involved in facilitating interaction and linkages between stakeholders (Kilelu et al., 2011; World Bank, 2012). Bridging organisations are defined by Berkes et al. (2003) as organisations that provide an arena for knowledge co-production, trust-building, sense-making, learning, vertical and horizontal collaboration, and conflict resolution.

From an innovation systems perspective, bridging organisations are regarded as intermediaries, which are "persons or organisations that, from a relatively impartial third-party position, purposefully catalyse innovation through bringing together actors and facilitating their interaction" (Klerkx & Gildemacher, 2012, p. 221). For many developing countries, it has been argued that agricultural bridging functions are best suited to, and easily assimilated by, public extension organisations, even though other organisations (e.g., private extension organisations, non-governmental organisations (NGOs), farmer-based organisations, and research institutions) have been involved in the role (Kilelu et al., 2011). In the case of Ghana, for extension organisations to assimilate the bridging role in line with the AIS-based approach (Abdu-Raheem & Worth, 2016; Sigman, 2015), they "are required to expand their role from that of a one-to-one intermediary between research and farmers" to that which "creates many-to-many relationships to facilitate access to knowledge, skills, services, and goods from a wide range of organisations" (Kilelu et al., 2011, p. 89).

However, various other actors in agricultural systems can also take on bridging functions. These include sector-focused networks, trade associations, special government programmes, consultants, input suppliers, and, with direct relevance to this study, ICTs (Kilelu et al., 2011; Klerkx & Gildemacher, 2012). ICTs can serve as bridging mechanisms (Hansen et al., 2014; World Bank, 2012), and can be leveraged by extension organisations and other extension actors in support of functioning better as bridging organisations and engaging in AIS-based extension service delivery.

Intermediation

Hansen et al. (2014) assess the ability of social media and other ICT-enabled tools to drive agricultural innovation based on six "social network functions": *networking*, *cooperating*, *co-producing*, *crowdsourcing*, *discussing*, and *engaging*. Using this framework, Hansen et al. (2014) engaged innovation systems experts to assess the extent to which different forms of social media and other web-based platforms (e.g., YouTube, ResearchGate, LinkedIn, Facebook, Twitter) support particular networking functions that may facilitate collaboration for sharing ideas and for mobilising knowledge and resources circulating in other arenas (Granovetter, 1973; Kaushik et al., 2018).

In the African context, ICTs have been found to facilitate aspects of AIS-based extension service delivery by enabling multiple actors to network and engage in joint needs identification, knowledge-sharing, and problem-solving to meet information needs in farming systems (Ajani, 2014; Fabregas et al., 2019; Munthali et al., 2018). Mobile applications have, for example, been recognised for their ability to improve value chain linkages (Ajani, 2014; Zwane, 2020), to build timely monitoring systems (e.g., with geo-referenced data) on environmental issues and production, and to provide timely advice to enable farmers to respond to farming challenges (Gbangou et al., 2020; McCole et al., 2014).

That said, it is important to note that, in general, most studies of the role of ICTs in agricultural extension focus on the use of specific ICT tools (typically mobile apps) to provide market, technical, and weather information to farmers, rather than on ICTs' impact, or potential impact, on the provision of AIS-based extension (Aker et al., 2016; Misaki et al., 2018). Furthermore, despite ICTs falling within the typology of intermediaries that can facilitate interaction and linkages between AIS actors to foster innovation, most studies of innovation intermediaries focus on the functioning and influence of other types of intermediaries, e.g., consultants targeting individual farmers and small and medium-sized enterprises (SMEs) in the agri-food sector; consultants targeting farmer collectives and agri-food SMEs; peer network brokers; education brokers; systemic intermediaries; and research councils (Kilelu et al., 2011; Kivimaa et al., 2019; Winch et al., 2007). Therefore, existing literature does not clarify which ICTs among those available in Ghana or other African countries are most capable of supporting the specific types of intermediation required to facilitate AIS-based extension service delivery activities in these contexts. Additionally, there has been little consideration of how experts, from the academically oriented to the more location-specific and practice-oriented, look at the potential of various kinds of ICTs to augment extension service delivery.

To address these knowledge gaps, our study explored the views of communication and innovation scientists, development informatics researchers, and ICT4Ag practitioners on the current opportunities for ICTs to enhance intermediation functions within agricultural extension service delivery in Ghana.

Analytical framework: Intermediation capabilities

The framework we deployed in the study builds on the aforementioned social network functions framework of Hansen et al. (2014). Our framework modifies the Hansen et al. (2014) networking functions—*engagement*, *discussion*, *crowdsourcing*, *networking*, *co-production* and *cooperation*—by:

- merging three overlapping functions (engagement, discussion, cooperation) into two broader functions (*coordinating* and *co-creating*); and
- including additional functions (*harvesting*, *matching*, *coordinating*) relevant to facilitating AIS-based extension delivery.

Overall, we broaden the work of Hansen et al. (2014) to reflect networking as well as communication functions relevant to facilitating AIS-based extension service delivery, and we refer to these functions collectively as intermediation capabilities. The seven intermediation capabilities in our framework—*disseminating (information)*, *retrieving (information)*, *harvesting (information)*, *matching (actors to services)*, *networking (among actors)*, *coordinating (actors)*, and *co-creating (among actors)*—are detailed below in Table 1.

Table 1: Intermediation capabilities

Intermediation capability	Description
Disseminating (information)	Enabling content to be spread widely, alerting or attracting the interest of or raising the awareness of a large group of geographically dispersed actors
Retrieving (information)	Enabling actors to retrieve information (e.g., price, weather) from a central database or to retrieve documents out of a central repository
Harvesting (information)	Enabling the gathering of feedback, ideas, and opinions through the contributions of a large group of geographically dispersed actors e.g., crowdsourcing or polling
Matching (actors to services)	Enabling supply and demand linkages – actors are able to query, consult, or search information systems and connect to advice or services
Networking (among actors)	Enabling contact between actors so that they make direct connections and are able to interact to form new (business) relationships or reinforce existing relationships
Coordinating (actors)	Facilitating virtual multi-actor engagement[4] to provide open and live communication channels that enable discussion for coordinated action e.g., acting together towards a common purpose or engaging in joint problem-solving
Co-creating (among actors)	Facilitating a common working space for multiple actors to combine and contribute contextual knowledge or information, and engage in document sharing and information storage towards a tangible output

Source: Adapted from Hansen et al. (2014), with insights from Leeuwis (2004) and Howells (2006)

Taking the intermediation capabilities listed in Table 2 as a reference, this study sought to answer the following research questions:

- How do experts assess the extent to which different ICTs support specific intermediation capabilities?
- What type of consensus or dissensus do experts reach over which ICTs can support which specific intermediation capabilities?
- What factors are contributing to consensus and dissensus among experts about which ICTs can support which specific intermediation capabilities?

4 Multi-actor engagement in this study refers to virtually connecting and placing more than one actor in a virtual "room" and around a virtual "table" where they can engage in, or take advantage of, one-to-many and many-to-many communication (i.e., have a back-and-forth exchange/interaction).

3. Methods

In this section, we report on the scoping exercise that was conducted to identify the ICTs currently being used in the Ghanaian agricultural system. The outcomes of this scoping study provided the basis for engagement with experts on their views. The section also explains the set-up of the Delphi-inspired study, which was designed to establish experts' consensus and dissensus with respect to the intermediation capabilities of the different types of ICTs that were identified through the scoping exercise.

Scoping exercise

We reviewed ICT4Ag literature on Ghana, and engaged with organisations rolling out ICT initiatives discovered in the literature, in order to identify the ICTs being used in the Ghanaian agricultural system (Aker et al., 2016; Gakuru et al., 2009; Qiang et al., 2012; World Bank, 2014). Through these scoping activities we developed an inventory of ICT4Ag platforms (see Appendix). We then examined the inventory and were able to identify nine different types of ICTs in use (see Table 2).

Table 2: Types of ICTs identified in Ghana's agricultural system

Type		Interface	Data format	Communication	Mobile device needed	Minimum network needed
short message service (SMS)	SMS pull	SMS request typing	text	one-to-one	any phone	2G
	SMS push	SMS based reading	text	one-to-many	any phone	2G
interactive voice response (IVR)	IVR inbound	request-based talking and listening	audio	one-to-one	any phone	2G
	IVR outbound	request-based talking and listening	audio	one-to-many	any phone	2G
unstructured supplementary service data (USSD)		request-based typing and reading	text	one-to-one	any phone	2G
social media messaging (SMM)		request-based typing and reading	text, audio, pictorial, video	one-to-many	smart phone	4G
data management (DaM)		data gathering	text, audio, pictorial, global navigation satellite system (GNSS)	one-to-one or one-to-many	smart phone	4G
document management (DoM)		document sharing	text, audio, pictorial, video, GNSS	one-to-many	smart phone	4G
spatial (Spa)		mapping	GNSS	one-to-one or one-to-many	smart phone	4G

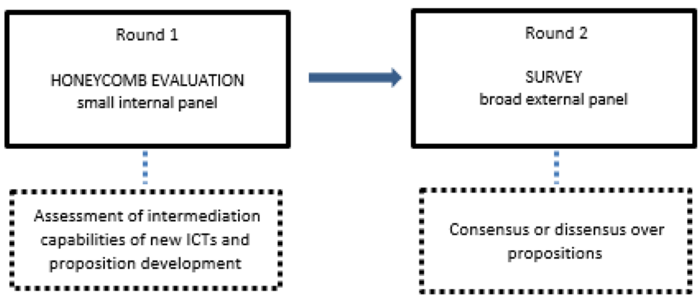
Delphi-inspired expert consensus-building study

Building on the scoping study, we developed an expert consensus-building method that was inspired by the Delphi study approach. A Delphi study is defined as "a method for systematic solicitation for judgements on a particular topic through a set of carefully designed sequential questionnaires interspersed with summarised information and feedback of opinions derived from earlier responses" (Chu & Hwang, 2008, p. 2828). It involves a "group facilitation technique, which is an iterative multistage process, designed to transform opinion into group consensus" (Hasson et al., 2000, p. 1) among experts (Benitez-Capistros et al., 2014). Benitez-Capistros et al. (2014) define an expert as a person who is competent as an authority on particular facts.

The content validity of the Delphi is enhanced by avoidance of data collection in a group setting where more dominant actors' opinions may be captured (Hasson et al., 2000). Furthermore, Delphi data collection involves more than one round of questioning, which increases concurrent validity of the method (Hasson et al., 2000), and because consensus-building is the objective of the Delphi approach, the number of these rounds is undefined and dependent on when consensus emerges or increases among participants (Benitez-Capistros et al., 2014). According to Hasson et al. (2000) and Doria et al. (2009), acceptable majorities in a Delphi-derived consensus can range from a basic majority (50–59%) to a low (60–69%), medium (70–79%) or high (≥ 80%) majority.

There are variations in the set-up of Delphi studies (Allen et al., 2019; Chu & Hwang, 2008). Our Delphi-inspired expert consensus-building method involved two rounds, and for each round the expert panel composition varied to fit a particular purpose (see Figure 1).

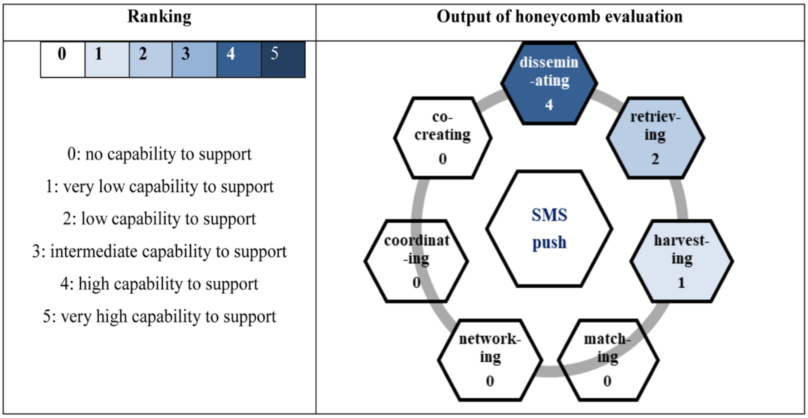
Figure 1: Summary of expert consensus-building method



First round: Honeycomb evaluation by internal panel of experts

The first round involved a small internal panel composed of the research team: four experts in the domain of communication and innovation science. The experts each individually engaged in a honeycomb evaluation to assess the intermediation capabilities of the various ICTs (see example in Figure 2) and ranked the different ICTs in relation to the seven intermediation capabilities in our framework. The ranking was based on a Likert scale ranging from "0" (no capability to support) to "5" (strong capability to support). Based on the individual honeycomb evaluations, we calculated the average rank assigned by the experts to each type of technology for each type of intermediation capability.

Figure 2: Example of honeycomb evaluation output (for "SMS push technology")



The aggregated and averaged results of the four internal experts' honeycomb evaluations were then presented to the entire internal panel to facilitate a convergence forum. The convergence forum gave the experts the opportunity to reflect on the aggregated results in relation to their individual responses, discuss areas of divergence, and ultimately reach agreement on the indicative intermediation capabilities of the different ICTs. The forum also enabled the experts to identify the significant results of the honeycomb evaluation from which 16 propositions were developed for the second round of the expert consensus-building method.

Second round: Online survey of 11 external experts
In the second round, the 16 propositions were packaged into a questionnaire format, using a five-point Likert scale that ranged from "1" (strongly disagree) to "5" (strongly agree). The questionnaire was presented to a broader expert panel made up of Ghana-focused development informatics researchers and ICT4Ag practitioners.

Potential respondents were identified from a list of invitees to a workshop convened in Accra, Ghana by the Environmental Virtual Observatories for Connective Action (EVOCA) research programme in April 2019, which targeted Ghanaian agricultural stakeholders. Additional researchers and practitioners were identified as potential respondents through a search in the SCOPUS abstract and citation database of peer-reviewed research literature. The search was composed of two steps: (1) a search using the function "(mobile technology or ICT) AND (extension or agriculture) AND (Ghana)"; and (2) screening the articles captured in the search to establish whether they were on topic and, where applicable, to identify authors who could be invited to participate in the survey.

In total, 22 potential respondents—13 researchers and nine ICT4Ag practitioners—were identified and sent an email invitation to engage in the study by completing the online questionnaire, which was administered via the web-based platform Google Forms. Of the invitees, 11 (five researchers and six practitioners—see Table 3) responded to the questionnaire during the two-week period given for responses.

Table 3: Eleven respondents

Respondent's organisation	Respondent's designation
Researchers	
Centre for Agriculture and Bioscience International, Ghana	junior researcher/project manager
University for Development Studies, Ghana	lecturer
Wageningen University, The Netherlands	PhD researcher (Ghana-focused)
Council for Scientific and Industrial Research, Ghana	junior researcher
Kumasi Institute of Technology Energy and Environment, Ghana	senior researcher
Practitioners	
Esoko, Ghana	senior manager
Grameen Foundation, Ghana	senior manager
Farm Radio International, Ghana	middle manager
Maclear Technology, Ghana	senior technical advisor
Ministry of Food and Agriculture, Ghana	district agricultural officer
Ministry of Food and Agriculture, Ghana	senior manager, extension directorate

For round two, the descriptive statistics analysed for each proposition included the mean (*qi*), the median (*Q2*), and the frequency of ranking for each point on the Likert scale. Based on these statistics, we determined whether there was positive consensus (agreement) or negative consensus (disagreement) about a proposition, or whether there was dissensus (varied ranking or polarisation) about a proposition. We considered three criteria to determine whether consensus was reached and to determine the direction of the consensus for each proposition (Table 4). These criteria were (1) the position of the mean on the Likert scale (Chu & Hwang, 2008); (2) the position of the mean in relation to the median in the data distribution (Chu & Hwang, 2008); and (3) the significance of the percentage of participants ranking a proposition on the Likert scale, ranging from low to medium to high to very high (Doria et al., 2009; Hasson et al., 2000).

Table 4: Criteria determining consensus over a proposition

Rule		Positive consensus	Dissensus	Negative consensus
1	Position of mean on Likert scale	$qi > 3.5$	$2.5 > qi < 3.5$	$qi < 2.5$
2	Position of mean in relation to median of data distribution	$qi <$ Q2, indicating there is a right-skewed distribution	Q2 < qi < Q3, indicating there is a normal distribution	$qi >$ Q2, indicating there is a left-skewed distribution
3	Position of majority ranking on Likert scale	very high consensus: ≥80% agree; high consensus: 70–79% agree; medium consensus: 60–69% agree	low consensus: 50–59% dis(agree) or <60% dis(agree)	very high consensus: ≥80% disagree; high consensus: 70–79% disagree; medium consensus: 60–69% disagree

Focus group discussion

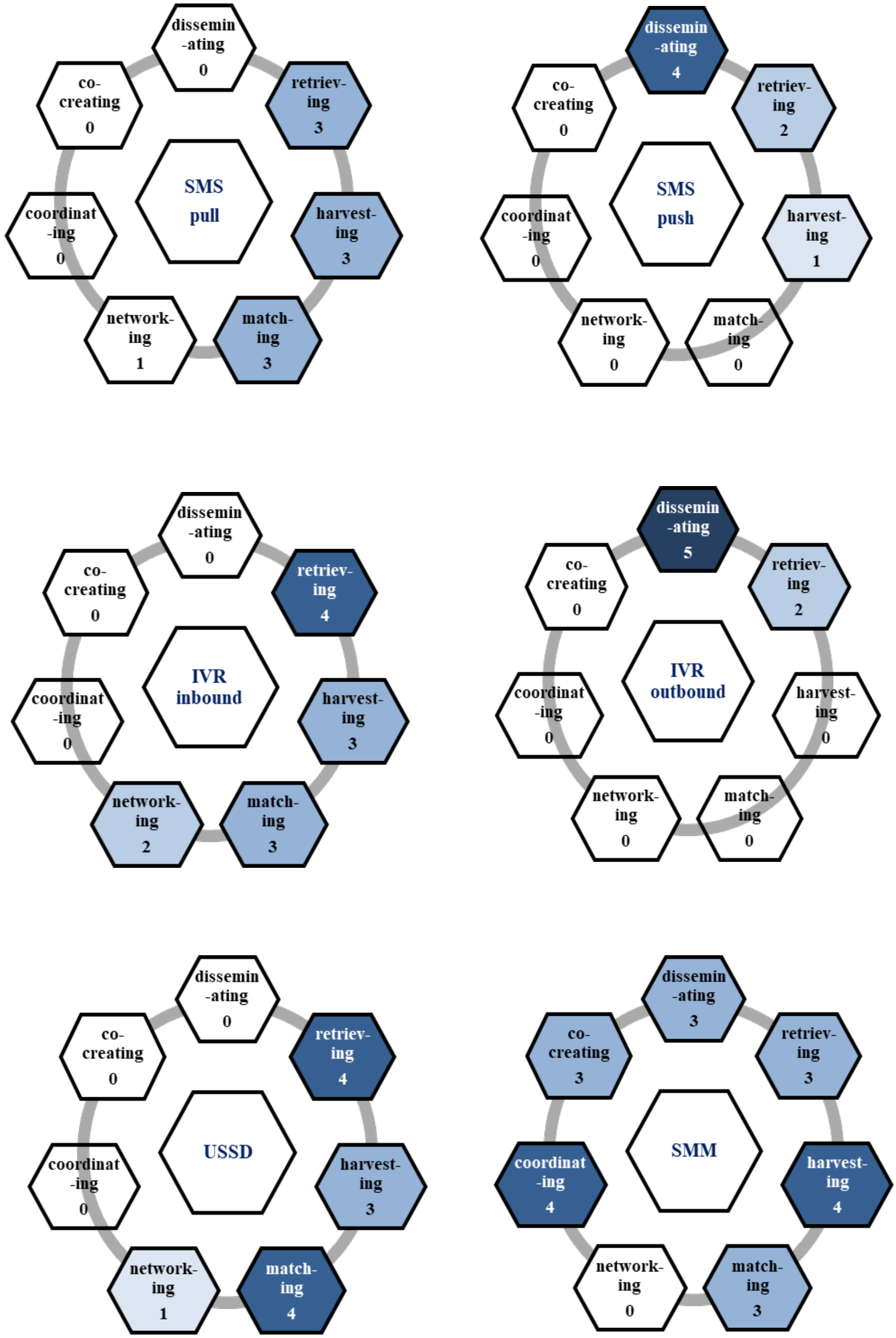
In addition to the expert consensus-building method, a focus group discussion was conducted to establish factors contributing to (positive or negative) consensus and dissensus (varying views or polarisation) over the propositions. The focus group discussion took place during the EVOCA programme's Ghana workshop. The workshop attracted 19 participants and, as part of the workshop proceedings, the participants were selectively split into four working groups that each comprised all the categories of participants present at the event (mainly various kinds of technology users). One of the working groups comprised five workshop participants who took part in the focus group: two public extension staff members, two ICT-based NGO representatives, and a small-scale farmer. We presented the aggregated questionnaire results to the focus group, and they reflected on the results and engaged in an open discussion on whether or not they agreed with them in general, and why. The discussion was recorded to facilitate thematic analysis of the plausible factors contributing to consensus and dissensus on the propositions.

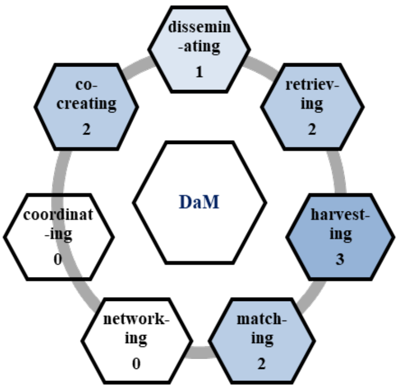
4. Findings

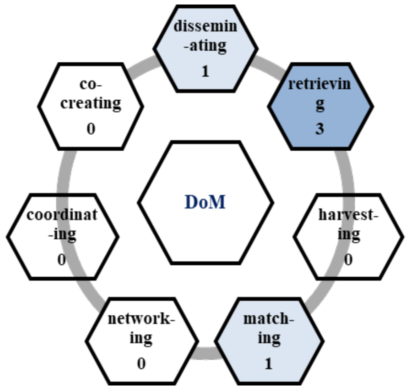
First round of consensus-building

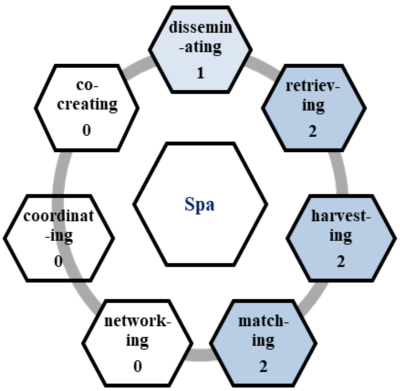
The first round of the expert consensus-building, with the four-person internal panel of experts, collated views on the intermediation capability (high to low) of each ICT identified in the Ghanaian agricultural system (see Figure 3). In terms of the ICTs with a high capability to support intermediation capabilities (ranking > 3), the aggregated results of the honeycomb evaluation show that interactive voice response (IVR) outbound technologies were viewed as having very high capability to support *disseminating*, and IVR inbound technologies were viewed as having high capability to support *retrieving*. In addition, short message service (SMS) push technologies were seen as having a high capability to support *disseminating*, and unstructured supplementary service data (USSD) technologies were viewed as having a high capability to support *retrieving* and *matching*. Furthermore, the aggregated results showed that social media messaging (SMM) technologies had a high capability to support *harvesting* and *coordinating*, and an intermediate capability to support all the other intermediation capabilities, excluding *networking*.

Figure 3: First round of consensus-building: Aggregated results of honeycomb evaluation (nine honeycomb images)









With respect to technologies found to have a low capability to support specific intermediation capabilities (ranking < 3), the panel of internal experts reached consensus that spatial (Spa) technologies generally had a low capability to support all the intermediation capabilities. The panel also reached consensus that SMS pull technologies, data management (DaM) technologies, and document management (DoM) technologies also did not rank highly (ranking > 3) in terms of their capability to support any intermediation. The assessment also found that all ICTs had a low capability to support networking.

Second round of consensus-building

Based on the aggregated results of the first round of consensus-building, the four-person internal expert panel developed a number of propositions, 16 of which (see Table 5) were used to develop the online survey questionnaire for the second round.

Table 5: The 16 propositions (P1 to P16) used in second round of consensus-building

Intermediation capability	Proposition	
Disseminating (information)	P1	At present, among all the ICTs identified, IVR outbound technologies have the highest capability for disseminating information to rural farmers.
	P2	At present IVR outbound technologies have higher capability than SMS push technologies for disseminating information to rural farmers.
	P3	SMM technologies have high potential to facilitate disseminating information to rural farmers in the next 10 years.
Harvesting (information)	P4	At present, among all the ICTs identified, IVR inbound technologies have the highest capability for harvesting information from rural farmers.
	P5	At present IVR inbound technologies have higher capability than USSD technologies for harvesting information from rural farmers.
	P6	SMM technologies have higher potential than IVR inbound technologies for harvesting information from rural farmers in the next 10 years.
Retrieving (information)	P7	At present, among all the ICTs identified, IVR inbound technologies have the highest capability for allowing rural farmers to retrieve information.
	P8	At present USSD technologies have the highest capability for rural farmers to retrieve information than the other types of technologies.
	P9	SMM technologies have high potential for rural farmers to retrieve information in the next 10 years
Matching (actors to services)	P10	At present, among all the ICTs identified, USSD technologies have the highest capability to match rural farmers to services.
	P11	At present IVR inbound technologies have higher capability than USSD technologies to match rural farmers to services.
Networking (among actors)	P12	At present all the technologies identified have low capability to facilitate networking between rural farmers and other agricultural stakeholders.
	P13	SMM technologies have high potential to facilitate networking between rural farmers and other agricultural stakeholders in the next 10 years.
Coordinating (actors)	P14	At present, among all the ICTs identified, SMM technologies have the highest capability to facilitate coordination between rural farmers and other agricultural stakeholders.
Co-creating (among actors)	P15	At present SMM technologies have intermediate capability to facilitate co-creating among rural farmers and other agricultural stakeholders.
	P16	SMM technologies have high potential to facilitate co-creating among rural farmers and other agricultural stakeholders in the next 10 years.

The propositions were also developed within a specific context to aid the panel of external experts in assessing which ICTs were likely to be best suited to facilitate certain communication and networking functions in extension activities. The internal panel (more academic-oriented), therefore, required the external panel of respondents (more Ghana-specific and practice-oriented) to envision themselves as district extension staff tasked by the "Ministry of Agriculture – Headquarters" to qualify or disqualify the preliminary assessment of the current capability and future potential of specific ICTs to improve extension service delivery involving rural farmers.

Experts' consensus on propositions

The results of round two showed that seven of the 16 propositions presented to the external experts were marked by positive consensus (Table 6). Additionally, the questionnaire results showed that there was no negative consensus among the external experts about any of the propositions.

Table 6: Propositions associated with positive consensus

Type of ICT	Proposition		Criteria for positive consensus		
			Crit. 1	Crit. 2	Crit. 3
			qi > 3.5	*qi* < *Q2*	(strongly) Agree %
IVR inbound	P4	At present, [...] IVR inbound technologies have the highest capability for harvesting information from rural farmers.	3.55 > 3.5	3.55 < 4	63.64
	P7	At present, [...] IVR inbound technologies have the highest capability for rural farmers to retrieve information.	3.73 > 3.5	3.73 < 4	72.73
	P11	At present IVR inbound technologies have higher capability than USSD technologies to match rural farmers to services.	3.73 > 3.5	37.3 < 4	81.82
IVR outbound	P1	At present, [...] IVR outbound technologies have the highest capability for disseminating information to rural farmers.	3.64 > 3.5	3.64 < 4	72.73
	P2	At present IVR outbound technologies have higher capability than SMS push technologies for disseminating information to rural farmers	3.73 > 3.5	3.73 < 4	72.73
SMM	P14	At present, [...] SMM technologies have the highest capability to facilitate coordination between rural farmers and other agricultural stakeholders.	3.82 > 3.5	3.82 < 4	72.73
	P15	At present SMM technologies have intermediate capability to facilitate co-creating among rural farmers and other agricultural stakeholders.	3.82 > 3.5	3.82 < 4	90.91
Abbreviations: qi = mean; Q2 = median					

As seen in Table 6, there was positive consensus among the experts that:

- IVR inbound technologies currently have the highest capability for *harvesting* information from farmers (P4), for supporting farmers in *retrieving* information (P7), and for *matching* farmers with advice and services (P11);
- IVR outbound technologies currently have the highest capability for *disseminating* information to farmers (P1); and
- SMM technologies currently have the highest capability to support *coordinating* between agricultural stakeholders (P14) including farmers, and intermediate-level capability to facilitate *co-creating* by these stakeholders (P15).

Experts' dissensus over propositions

The experts did not reach consensus on nine of the 16 propositions (Table 7). This dissensus was determined on the basis that the propositions failed to meet all three of the consensus criteria outlined earlier.

Table 7: Propositions associated with dissensus

Type of ICT		Proposition	Criteria for dissensus					
			Crit. 1	Crit. 2		Crit. 3		
			2.5 > qi < 3.5	Q2 < qi	qi < Q3	(strongly) Disagree %	Neutral %	(strongly) Agree %
IVR inbound	P5	At present IVR inbound technologies have higher capability than USSD technologies for harvesting information from rural farmers.	2.5 > 3.36 < 3.5	4 > 3.36	3.36 < 4	18.18	27.27	54.55
USSD	P8	At present, [...] USSD technologies have the highest capability for rural farmers to retrieve information.	2.5 > 2.73 < 3.5	2 < 2.73	2.73 < 4	54.55	9.09	36.36
	P10	At present, [...] , USSD technologies have the highest capability to match rural farmers to services.	2.5 > 2.73 < 3.5	2 < 2.73	2.73 < 4	54.55	9.09	36.36
SMM	P3	SMM technologies have high potential to facilitate the dissemination of information to rural farmers in the next 10 years.	2.5 > 3 < 3.5	3 ≥ 3.00	3.00 < 3.5	36.36	36.36	27.27
	P6	SMM technologies have higher potential than IVR inbound technologies for harvesting information from rural farmers in the next 10 years.	2.5 > 3.18 < 3.5	3 < 3.18	3.18 < 4	18.18	36.36	45.45
	P9	SMM technologies have high potential for rural farmers to retrieve information in the next 10 years.	2.5 > 3.18 < 3.5	4 > 3.18	3.18 < 4	36.36	9.09	54.55
	P13	SMM technologies have high potential to facilitate networking between rural farmers and other agricultural stakeholders in the next 10 years.	2.5 > 3.27 < 3.5	3 < 3.27	3.27 < 4	36.36	18.18	45.45
	P16	SMM technologies have high potential to facilitate co-creating among rural farmers and other agricultural stakeholders in the next 10 years.	2.5 > 3.55 > 3.5	4 > 3.55	3.55 < 4	18.18	27.27	54.55
All	P12	At present all the technologies identified have low capability to facilitate networking between rural farmers and other agricultural stakeholders.	2.5 > 2.55 < 3.5	2 < 2.73	2.55 < 4	54.55	0.00	45.45

Abbreviations: qi: mean; Q2: median; Q3: "middle" value in the second half of the rank-ordered data

Specifically, as seen in Table 7, it was found that experts had varied views on:

- whether IVR inbound technologies currently have a higher capability than USSD technologies to facilitate the *harvesting* of information from rural farmers (P5);
- the current capability of USSD technologies to facilitate *retrieving* of information by rural farmers (P8), or to facilitate *matching* of farmers with agricultural services (P10);
- the current capability of all the technologies identified to support *networking* between rural farmers and other agricultural stakeholders (P12);
- the future potential of SMM technologies to facilitate *disseminating*, *harvesting* and *retrieving* information targeted at or involving farmers (P3, P6, P9); and
- the future potential of SMM technologies to support *networking* and *co-creating* between agricultural stakeholders (P13, P16).

Focus group findings: Factors contributing to consensus and dissensus

Consensus on high capabilities of IVR technology

The focus group discussion revealed two factors contributing to the external experts' consensus on the high intermediation capabilities of IVR inbound and outbound technologies at present, as described above. One factor was that IVR technologies operate on basic and feature mobile phones (i.e., non-smart phones) that are accessible to rural Ghanaian farmers. The other factor was that IVR technologies, unlike SMS or USSD technologies, generate audio as opposed to textual content. This makes them more compatible with the generally low literacy levels of the farmers. In the words of one focus group participant:

> At the moment, IVR is known widely and used because it is programmed in a language that the end user understands. It does not involve text messages and is available on any kind of phone.

Consensus and dissensus on capabilities of SMM technology

The focus group also established the reasons behind experts' consensus on certain intermediation capabilities of SMM technologies and dissensus on other SMM capabilities. The consensus on the high capability of SMM technologies to support *coordinating* between agricultural stakeholders, at present, was found in the focus group to be a result of the view that SMM technologies facilitate, to a greater extent than other ICTs, rapid and easy interaction and feedback. Another reason for the consensus on the high capability of SMM for coordinating, at present, was the assumption that most coordination functions involve service providers (e.g., extension agents) working together with lead farmers, i.e., with lead farmers who, because they have higher literacy levels and greater financial means than the average farmers, are likely to have access to the smartphones necessary for the use of SMM technologies. According to a focus group participant:

> Social media applications are the medium of swift information exchange and facilitation at the moment. […] because of the infiltration of cheaper smartphones [...] most lead farmers have this platform [WhatsApp], which makes them easily organise meetings, and solicit for assistance and information from each [agricultural] actor when need be.

Meanwhile, the consensus on SMM technologies' current capability to support *co-creating* was that the capability is only at an intermediate level. On this point, it was found in the focus group that the experts took into consideration that many rural farmers currently lack access to smartphones that support the use of SMM technologies, and also that the generally low levels of literacy of farmers affects their ability to engage intensively with or on SMM technologies. In relation to these challenges with farmers taking advantage of SMM technologies, some experts pointed to alternative communication mechanisms, such as face-to-face meetings, being more appropriate than SMM, at present, for facilitating co-creation involving rural Ghanaian farmers.

Moving to the factors contributing to the dissensus regarding the future intermediation capabilities of SMM in *disseminating*, *retrieving*, and *harvesting* information, the variation in views was found in the focus group to be due to different levels of optimism among the focus group participants on rural farmers' future access to smartphones and the farmers' future literacy levels. The more optimistic respondents were confident in farmers' increased access to smartphones and increased literacy over the next 10 years. Representing the optimistic view, one focus group participant argued as follows:

> [...] but it [the situation] is not static. Maybe in 10 years the youth will become more active farmers and be more inclined to use WhatsApp.

However, pessimistic views were also expressed. For example, one focus group respondent stated:

> [...] right now it has been tagged that you [farmers] need a lot of money to get a smartphone, let alone the [poor] internet connectivity within rural areas.

Another focus group participant added an additional pessimistic view:

> I am not even looking at the costs of [mobile data] bundles. Let's look at how old the active rural farmers will be and what their educational level will be. When you talk about the farmers now, most of them are within the range of 30–35 and they will be 40–50 in the next 10 years. In the next 10 years we will be dealing with the same crop of farmers. Therefore, I do not expect to see significant changes in relation to their adoption of such new technology [SMM technologies].

5. Discussion and conclusion

The starting point of this study was that ICTs have the capacity to respond to information- and interaction-related needs in Ghana's agricultural extension service delivery. Through the inputs of a total of 15 varied experts in two rounds, we assessed the capability of nine types of ICTs operating in Ghana to support specific communication and networking functions (intermediation capabilities) that are required to facilitate AIS-based extension service delivery. In this section we highlight the results, specifically instances of positive consensus and of dissensus, in experts' views on the intermediation capabilities of the ICTs identified, and discuss these instances with reference to the reasoning provided by the focus group participants and in the context of existing literature. Based on this analysis and discussion we point out opportunities for specific ICTs to support certain communication and networking functions that are required to facilitate AIS-based extension service delivery, as well as alternative scenarios. Finally, this section reflects on the validity of the Delphi-inspired research design and highlights potential areas for future research.

Positive consensus over technologies' intermediation capabilities

Below we discuss and identify opportunities for IVR and SMM technologies to support intermediation.

IVR technologies

The results show that experts reached positive consensus on the high capability of IVR technologies to support *disseminating*, *retrieving*, and *harvesting* information, at present, and to support *matching* actors to services targeted at rural farmers, also at present. These findings are congruent with previous research pointing to IVR technology having great potential to reach farmers directly (Dittoh et al., 2013; McNamara et al., 2014). It is clear that many scientists, researchers, and practitioners view IVR technologies as being appropriate for supporting these specific communication functions involving rural communities. This is largely because, as found in our focus group discussion and also as argued in the literature, these technologies are audio-based and thus fit rural farmers' literacy levels, and these technologies are supported by the low-cost basic and feature mobile phones that most rural farmers can readily access (Aker et al., 2016; Dittoh et al., 2013; Schmidt et al., 2010).

SMM technologies

We also found that there was positive consensus among experts on the high capabilities of SMM technologies to support *coordinating* between farmers and other agricultural actors at present. Therefore, in this case, it is also clear that various experts, including Fabregas et al. (2019), see opportunities for SMM technologies to support the coordination of activities involving farmers and other agricultural actors. Furthermore, according to the focus group and other studies, the consensus reported is due to SMM technologies enabling speedy information dissemination and immediate feedback (Bennett & Segerberg, 2012; Munthali et al., 2018; Stevens et al., 2016).

However, despite the full spectrum of SMM technologies' features, the study found that these technologies only have the potential to support a certain type of coordinating—not as defined in Table 2. The focus group reported that SMM technologies tended to be used by lead farmers to interact with agricultural stakeholders (other than farmers) on a one-on-one basis. Specifically, focus group participants indicated that lead farmers use SMM technologies for speedy one-to-one communication with these other agricultural stakeholders to support aspects of coordination (e.g., organising meetings)—as Martin and Hall (2011) also report—as opposed to using the technologies to facilitate many-to-many communication to support, for instance, multi-actor (stakeholder) knowledge exchange and joint problem-solving. The SMM technologies were not cited as having the potential to facilitate virtual, multi-actor open and live communication for coordinated action to solve emerging problem. Thus, there are indications that the possibilities of leveraging SMM technologies' ability to facilitate multi-actor discursive spaces are currently limited in Ghana's extension practice.

Last, various experts were of the collective view that at present SMM technologies have only intermediate capabilities to support *co-creating* involving rural farmers and other agricultural stakeholders. Thus, the experts saw SMM technology as currently having neither high nor low capability to support the co-creating function, which requires multi-actor engagement and many-to-many communication. The focus group participants provided insights into factors contributing to this survey outcome. Certain focus group discussants were optimistic about farmers' educational levels and smartphone access increasing in the near future, thus allowing farmers to engage with SMM technologies that have the technical capacity to support engagement and communication for co-creating. Other focus group participants held a pessimistic view on the matter.

Dissensus over technologies' intermediation capabilities

Experts did not reach positive or negative consensus on a number of propositions. They had a mix of positive, neutral, and negative views on these propositions. We now discuss and identify these instances of dissensus in relation to intermediation via IVR, USSD, and SMM technologies.

IVR technologies

There was dissensus among the experts in our study on whether IVR inbound technologies have a higher capability than USSD technologies to support *harvesting*, at present. At the same time, and as already mentioned, there was positive consensus among the experts that IVR inbound technologies have the highest capability, among all the technologies identified (including USSD), to support this communication function. A plausible explanation for these inconsistent findings is that experts judged IVR inbound and USSD technologies, comparatively, as possessing equal technical abilities to support harvesting, but when explicitly asked which technology had the highest potential to retrieve information directly from farmers in the Ghanaian context, they identified IVR inbound technologies. Moreover, the existing literature, the analysis in the previous section on positive consensus, and the focus group inputs all point to a finding that IVR inbound technologies are best suited to support direct harvesting of information from Ghanaian rural farmers as these technologies support audio content and operate on basic mobile phones (Aker et al., 2016).

USSD technologies

We found that there was no consensus among experts regarding USSD technologies' capability, at present, to support farmers in *retrieving* information or *matching* actors (farmers) to services over other ICTs. This dissensus was based on the competing pessimistic and optimistic views of experts on farmers' literacy levels. Meanwhile, the focus group and the literature point to IVR technologies having higher capacity to support these communication functions in comparison to other technologies. For example, Perrier et al. (2015) state that IVR technology is better-suited than USSD to reach literacy-constrained audiences.

SMM technologies

There was also dissensus among experts on the future potential of SMM technologies to support *disseminating*, *harvesting*, and *retrieving* targeted at rural farmers, or *networking* and *co-creating* involving rural farmers and other agricultural stakeholders. This outcome could be attributed to the competing and diverging views of experts, as already mentioned above, on the future dynamics of farmers' access to, and use of, the mobile smartphones that support these technologies.

For the networking function specifically, the findings above related to SMM technologies—and the dissensus found on the propostion that all the technologies identified have low capability to support networking at present—lead to the conclusion that it is unclear which ICTs are best suited to support the function.

Unlike the aforementioned findings on experts' views on the possibility of leveraging SMM technologies to support networking in the Ghanaian context, the Hansen study (Hansen et al., 2014) found that social media currently has high potential, in the European context, to support networking and co-creating. The difference between the Hansen at al. (2014) findings and those of this study point to two issues that require consideration. The first issue is that the findings of the European-focused study could largely be influenced by the context—a context in which farmers have higher literacy levels and easier access to smartphones than farmers in most African countries (ITU, 2021). The second issue is that at present, as suggested by this study's focus group participants, networking intermediation capabilities are likely to be best-supported, in contexts such as those found in Ghana, by alternative communication mechanisms such as conventional face-to-face meetings, which remain relevant in the functioning of agricultural systems where intensive interaction is required (Leeuwis et al., 2018; Materia et al., 2015). Such communication mechanisms have been cited (Molony, 2006) as trusted social networking methods that, in the African context, are the most appropriate modes of interaction given the prevailing literacy levels and types of mobile phones owned in rural agricultural settings (Dittoh et al., 2013).

Validity of the consensus-building method

It is necessary to reflect on the validity of the expert consensus-building method that we applied in this study. In line with Delphi's general principles, our consensus-building method included more than one round of individual responses by experts (Hasson et al., 2000). However, our approach deviated from a typical Delphi in that it did not require that the same experts be involved in each of the two rounds. For our method, each set of experts was engaged for the distinct purpose of one round, so that we fostered concurrent validity by aggregating the views of a small group of experts in the first round and then presenting these views, for affirmation and/or refutation, to a broader expert panel in a following round. We developed this approach so as to allow the views of the internal expert panel (communication and innovation experts) to be subjected to assessment by experts who are more engaged than the internal panel with the Ghanaian context, and so as to be able to establish consensus and dissensus among a wide range of experts. Furthermore, a Delphi study is typically considered valid based on the input of 16 to 60 experts (Hasson et al., 2000). However, lower numbers of experts have been reported in other Delphi studies (Benitez-Capistros et al., 2014). It is our view that the inputs of the 15 experts in this study provide valuable insights because the design of the consensus-building method fostered concurrence validity.

Future research

Opportunities for future research can be identified from this study. Further research could shed light on ICTs' application and role in supporting broader (AIS-based) extension service delivery. This study is an experts' assessment of the intermediation capabilities of technologies identified in Ghana and provides insights into how experts view specific ICTs' potential to support communication and networking functions relevant to AIS-based extension service delivery. Going forward, empirical research is recommended to establish how the technologies practically support extension activities involved in AIS-based extension service delivery, in a variety of contexts.

Based on the findings of this study and related literature, it is probable that certain ICTs can currently support certain AIS-based extension activities. IVR technologies may support the broadcasting of knowledge and early warning alerts to rural stakeholders as part of coordination efforts in problem-solving, and enable the stakeholders to retrieve knowledge and other information (e.g., on weather, prices) (Aker et al., 2016). IVR technologies could also match farmers with service providers and suppliers, as well as allow for the harvesting of information from farmers and other rural stakeholders (Viamo, 2020) as inputs for systemic problem diagnosis. On the other hand, the technologies identified do not seem to have the potential to support multi-stakeholder engagement for collaborative problem diagnosis and problem-solving. This is based on two considerations: (1) this study found no clarity on whether any of the ICTs identified support the *networking* function; and (2) SMM technologies currently have the potential to largely support only one-to-one communication and coordination. Furthermore, given this study's finding that SMM technologies have only an intermediate capability to support *co-creating*, it is therefore unclear whether these technologies can fully support the combining of knowledge to facilitate innovation among agricultural stakeholders in extension practice.

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Appendix: Inventory of ICT4Ag platforms identified

Platform, services	**Constituent ICTs**
E-agriculture https://www.e-agriculture.gov.gh/ Direct to farmers: ○ E-farm – farmer audio agricultural information library ○ Call centre – access to subject matter specialists ○ Farmer engagement platform Extension provision: ○ Web portal – repository of value chain actors, service providers, and stakeholders; and dissemination of new technologies and agricultural current affairs ○ E-extension – to collect farmers' geo, bio, and crop data; and digitise field and pest and disease monitoring reports ○ E-subsidy – electronic registration of farmers with GPS integration and unique ID generator to facilitate efficient fertiliser subsidy distribution	IVR inbound DaM SMM Spa
AgroTech SmartEx Trader and outgrower schemes: ○ Farmer discovery and enrolment with GPS integration – farmer registration, and records of farm practices and credit activities ○ Farmer management – protocol of agent routine tied to key crop growth stages of farm operations to deliver timely support ○ Value chain and service linkages – access to agribusiness service providers and value chain actors ○ Information and knowledge repository – collection of technical information on crop production, processing, and marketing ○ Monitoring, evaluation, and learning – analyse farmer data to learn their needs and requirements, and track their performance. Additonally, tracking of agents' activities through a dashboard	DaM DoM Spa
Esoko https://www.esoko.com/ Direct to farmers: ○ Market prices and weather ○ Agronomic tips ○ Buy and sell marketplace – reach agent through call centre, sorted by location, commodity, quantity and grade, and place offer that is SMS to buyer(s) ○ Farmer Helpline call centre – access to agri-extension experts, market prices, and weather forecasts Extension provision: ○ Knowledge plus – knowledge respository templates ○ Insyts – digitised reporting templates and real-time analytics ○ Real-time message alerts Business-to-business services – for government institutions, NGOs, social projects: ○ Buy-and-sell marketplace – reach agent through call centre and place offer that is sent to farmers via SMS ○ Targeted marketing messages, announcements, and alerts ○ Polling and feedback ○ Knowledge repository templates ○ Digitised reporting templates	SMS push IVR inbound IVR outboud SMS pull DoM DaM Spa

mFarms https://www.mfarms.org/solutions/ Direct to farmers: ○ Commodity and agri-input prices ○ Precision agriculture ○ M-Xtension – provides good agricultural practices ○ Farmer to market – facilitates linkage between farmers, and input and ouput markets through human agents To extension providers, agro-dealers, seed producers, off takers: ○ Field agent management – agent database development and service provision/activity tracking ○ Farm-level monitoring – farmer database development with farm mapping and farming activity Business-to-business services – for NGOs, FBOs, agro-dealers, logistics or warehousing companies, aggregators, processing companies: ○ Targeted advertising and messaging with instant delivery reports and dashboards ○ Targeted short surveys and polling for organisations (NGOs, input suppliers, etc.) to track their performance ○ Warehousing, and stock and sales tracking systems ○ Loan management systems ○ Fleet management systems	SMS pull SMS push DaM IVR outbound Spa
Plantwise https://www.plantwise.org/KnowledgeBank For plant health and protection institutions and extension providers: ○ Plantwise factsheet – repository of crop-based pest and disease management advice ○ Plantwise data collector – digitised "prescription form" to record farmers' biodata, plant health problem diagnosis and prescriptions ○ Plantwise plant doctors' platform – pest and disease alert and knowledge-sharing platform	DoM DaM SMM Spa
Scientific Animations Without Borders (SAWBO) https://sawbo-animations.org/home/ For extension providers: ○ Video library – extension information accessible as 2D, 2.5D, and 3D animations with voice overlay	DoM
Complete Farmer https://www.completefarmer.com/ For farmers: ○ Builds and manages farms for individuals and provides real-time monitoring sensor and drone feed data through an online dashboard	DaM Spa
QualiTrace https://www.facebook.com/QualiTrace/ For input buyers: ○ Anti-counterfeiting solution – enabling input buyers to confirm the authenticity of farm inputs by dialling the barcode of the purchased product through a USSD application prompt	USSD
Akokotakra https://akokotakra.com/app For farmers: ○ Mobile and web-based management system that enables poultry farmers to record, monitor, and track their operations	DaM Spa

Ghalani https://www.facebook.com/ghalaniapp/ For farmers and agri-businesses: o Electronic management of farm records	DaM Spa
TROTRO Tractor https://www.trotrotractor.com/ For farmers: o land preparation, planting, spraying, threshing, shelling, and transportation services	USSD IVR inbound
Ignitia Iska https://www.ignitia.se/ Direct to farmer: o Location-specific weather updates – daily, monthly, and seasonal rain forecasts	SMS push
Farmerline https://farmerline.co/ Direct to farmers: o Weather forecasts o Agronomy tips – customised to location (GPS) and production stage o Market prices o Market place – access to farm inputs, water, solar energy, and financial services – aggregated demand for inputs (type and location) for Farmerline to supply goods Business-to-business – off takers, input dealers, global food companies, government institutions, research organisations, NGOs, financial institutions: o Polling and short surveys o Engagement platform – send customised bulk messages o Data collection, management, and analytics – including farm-level monitoring, field monitoring, farmer profiling, and farm mapping through delivery o Building credit history to access advanced financial services through a mobile money payment platform o Mobile payments and savings platform o Plant health and vegetation change monitoring using satellites	SMS push USSD IVR inbound IVR outbound DaM Spa
Moringa https://moringaconnect.com/ Extension provision: o In-house electronic data collection form and analytics, paired with GIS mapping system to monitor plant growth and trace moringa trees from planting to processing	DaM Spa
MTN MoMo (e-wallet) https://mtn.com.gh/momo/ Direct to farmers: Mobile banking – payments, loans and savings, micro insurance Business-to-business: o Mobile banking – payments, loans and savings, micro insurance	USSD
VOTO Mobile (Viamo) https://viamo.io/services/information-sharing/ Direct to farmers: o Mass-messaging on good agricultural practices o Mass-messaging on price information and weather forecasts Business-to-business: o Mobile data collection – track field activities, monitor disaster response, report on stock levels, measure attendance, follow-up on referrals o Polling priorities, needs, and feedback from farmers or stakeholders o Mass-messaging to advertise and inform farmers or stakeholders	SMS push USSD IVR outbound DaM Spa

Farm Radio International https://farmradio.org/ghana/ Direct to farmers: ○ Access to messages, alerts, radio programme segments, and ability to leave audio message ○ Commodity-based farm tips For radio stations and businesses: ○ Conduct surveys using audio messages ○ Farmer feedback on radio broadcasts ○ Uliza polling – voting by beeping/flashing to two phone numbers desginated for a "yes" or "no" response – listeners use basic phone to vote on IVR system, view results and recording. Number announced on radio station – call number and answer with number or record, flash call back ○ Automated callback or SMS with market information	IVR outbound IVR inbound SMS pull SMS push
Manobi Africa https://www.manobi.com Direct to farmers: ○ Listing and precise georeferencing of farming plots ○ Marketplace (offers and demands) between large and small producers, and traders, buyers, and importers ○ Real-time monitoring of prices of agricultural products in wholesale and retail markets ○ Epidemic alerts, weather forecasts, calculation yields Extension provision: ○ Data collection – digitised monitoring data on agricultural operations during crop production Business-to-business: ○ Collaborative platforms – facilitate multi-actor engagement for cooperatives, associations, etc. ○ Data collection – surveys and advanced monitoring and evaluation ○ Inventory management system	DaM SMS push Spa
CocoaLink https://www.hersheytrading.ch/en_us/good-business/creating-goodness/cocoa-sustainability/cocoa-link.html Direct to farmers: ○ Farmers can send in (photo) inquiries directly to experts and other farmers ○ Farmers receive weekly messages (farming practices, farm safety, child labour, crop disease prevention, post-harvest production, and marketing) from COCOBOD ○ Digital access to educational content – planting tips, correct input usage, and descriptions of best practices Extension provision: ○ Electronic farmer data collection	SMS push DaM DoM Spa IVR outbound
Farmforce https://farmforce.com/ Out-grower schemes and NGO (groups or cooperatives or exporters) – agent ○ Crop growth stage, pest scouting and monitoring results, bio-data, input usage, and recording or estimating harvests / yields ○ Manage micro-loans and perform audits ○ Historical information of where crop came from at supermarket level ○ Tracking specific produce through the value chain ○ Bulk messaging to field staff and farmers ○ Electronic (field audit) survey	SMS push DaM Spa

Freedom Fone https://archive.flossmanuals.net/freedom-fone/what-does-freedom-fone-do Direct to farmers: o Sharing audio information with an audience – educational dramas, market information, recorded radio programmes, or short news items For businesses: o Polling – enable audience to vote on an issue using their phone o Collect SMS feedback from audience – updates about specific news events, alerts, or time-critical information o Get your audience to leave audio messages to share their opinion on a particular topic or make reports in their own language (IVR inbound)	SMS pull IVR outbound IVR inbound
SavaNet https://savanet-gh.org/?q=content/what-we-do Direct to farmers: o Farmer group linkage to extension agents, ICT professionals, and researchers etc. (conference using mobile phone and portable external speakers) o Farm area mapping and analysis o Soil testing and analysis o Record keeping o Market access and weather forecasts	Spa DaM
SyeComp https://syecomp.com Business-to-business and service to NGOs: o Farmland surveying o Farm mapping o Certification support and traceability	Spa
GeoTraceability Extension service provision: o Tailored business plans – processing field data and agronomic practices to generate appropriate recommendations for business plans Business-to-business or project services: o Survey design tools and electronic data collection o Mapping production areas and relevant infrastructure o Traceability tools o Tailored messages to targeted groups of producers o Interoperating data from multiple platforms and data sources onto one database o Cloud-based data management structure to securely store and recall unlimited amounts of data	SMS push DaM Spa
Anitrack and Animat https://gh.linkedin.com/company/anitrack Direct to farmers: o Anitrack: a web application that enables animal identification, and health tracking of livestock using sensors (wearable tracking devices around the neck of the animal) to monitor vitals such as temperature and report when necessary sensors go off – sending a message to a registered veterinarian o Animat: a website for livestock producers to place their stock online for buyers to see	SMS push DaM Spa