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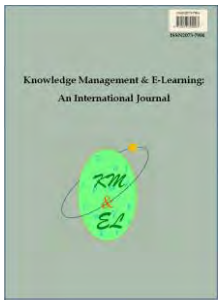

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Knowledge sharing technologies for rice farmers: A perspective from the Eastern Region of Ghana

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Abstract: This article investigates technologies used for knowledge sharing among rice farmers in the Eastern Region of Ghana and suggests ways by which the use of technologies may be enhance rice farming. The research was underpinned by the pragmatic paradigm where a concurrent triangulation mixed method design was adopted. The data was drawn from 101 survey respondents and nine interview participants, consisting of rice farmers, farm managers and extension officers. The findings revealed elementary use of technologies, tools and systems for knowledge sharing among the rice farmers. The main social media platform used for knowledge sharing was WhatsApp. The platforms that were used the least were Twitter, Facebook, LinkedIn, Imo and Instagram. Findings have implications for integrating various tools, technologies and systems into knowledge sharing among rice farmers. There is a need to address the challenges in structural-level technological infrastructures, architecture and functionalities, in order to build the technological competence of rice farmers. Farmers' knowledge of technology is influenced by training, motivation, and personal experiences. Previous studies on use of technologies in knowledge sharing focused on organisation. This article examines technology within the context of rice farming.

Keywords: Knowledge sharing; Technologies; Knowledge management; Rice farmers; Agriculture; Ghana

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1. Introduction

Agriculture is a driver of economic transformation in countries across the globe and there has been increasing efforts to achieve efficiency in agricultural farming with technology. Rice farming constitutes a critical part of the agricultural sector in most countries and technologies are key to the access and sharing of agricultural knowledge among rice farmers and other farmers whose households depend on agriculture for their livelihoods. Goals 2 and 13 of the Sustainable Development Goals (SDGs), developed by the United Nations in 2015, seek to ensure food security and improve climate change adaptation strategies respectively. Rice farming have a significant impact on addressing food security given that rice is one of the most consumed food products in the world.

Technological advancement in the field of agriculture has played a pivotal role in the ways that allow farmers to improve farming practices and productivity (Otsuka, 2019). This is even more so in rice farming, within low- and middle-income countries, where rice farming is going through a paradigm shift to embrace technology in rice production (Wijitdechakul, 2018). The use of agricultural technologies amongst rice farmers will enhance knowledge sharing increase productivity, efficiency, and competitiveness making it profitable and sustainable thus uplifting the agricultural communities. Technologies are defined as hardware and software tools and machines that are used to solve real-world problems (Tsinigo & Behrman, 2017). In the contexts of this article, technologies are conceptualized as information communication technologies (ICT) and include digital, eLearning and e- agriculture technologies.

The 2015 eLearning Africa highlights the significant role of productivity and efficiency of the continent's agriculture in terms of improving farming practices, food security and sustainability, as well as boost yields and improve income. The 2019 eLearning Africa conference e announced the importanceof special programme of seminars, discussions and debates about learning and training for Africa's farming and food sector (E-Agriculture, 2019).

The successful adoption of e-learning systems for agriculture is mainly dependent on the learners' attitude and willingness to use them. (Abdul-Razzaq & Salman, 2018). Factors that contribute to the formation of learners' attitude towards e-learning are personal, environmental, and technical determinants (Ahmadpour et al., 2016).

Agricultural technologies simply put are productivity-enhancing technologies that bring efficiency in farming processes and leads to higher yields in productivity in climate-free ways (Otsuka, 2019). These technologies provide access to tools, platforms and systems that promote knowledge dissemination, knowledge creation and knowledge sharing in agriculture. Agricultural technologies ensure that there is less chemical leaching in provident waters, less social erosion, lower water requirements and higher agricultural yields (Eberhardt & Vollrath, 2018).

Agricultural technologies include agricultural biotechnology, technology-based irrigation systems, improved fertilizer application technologies and weed management technologies that bring efficiency in farming and sustainable protection of land and climatic conditions (Nagothu et al., 2018). Other agricultural technologies include soil and water sensors, weather tracking technologies, satellite imaging, pervasive automation,

minichromosomal technology, and vertical farming (Otsuka, 2019; Eberhardt & Vollrath, 2018; Yan et al., 2015).

These technologies improve agricultural extension work, support agricultural extension system and transform agricultural work to electronic government and electronic management of human resources (Abdul-Razzaq & Salman, 2018). Agricultural technologies have the potential to support agricultural development in developing countries by providing innovative solutions to agricultural challenges. e-agriculture is no longer a luxury, but rather tantamount to every farmer's profitability and existence. (IT News Africa, 2015).

There are fundamental variations in the distribution of agricultural knowledge infrastructure between countries, within communities and among individuals (Mtega & Ngoepe, 2019). This means that some individual farmers and farming communities can be rich in agricultural knowledge, while others can be poor in agricultural knowledge. Therefore, the sharing of technological agricultural knowledge among smallholder rice farmers is a critical factor in transforming and improving rice production.

Since independence, the agricultural sector in Ghana has been the major annual contributor to both the gross domestic product (GDP) and employment rate. The sector contributes between 35 to 40% of Ghana's GDP and provides livelihoods for an estimated 57% of the total labour force (Cadger et al., 2016). Rice constitutes an important part of the main food crops in Ghana, alongside others like cassava, corn, yam and other root crops. Rice farming constitutes a critical and growing part of the Ghanaian agricultural sector. The government of Ghana is vigorously pursuing rice productivity-enhancing technologies for rice production One of the technologies in this regard is the improved rice variety technology which acts as a complementary input with established optimum fertilizer requirement levels, weed management regime, and planting density for farmers to adopt (Tsinigo & Behrman, 2017).

Even though there are governmental efforts in integrating technologies in rice farming, the technologies thus far focus on soil and seed technologies such as the improved rice variety technology. There are several technologies that have not been exploited in rice farming in Ghana, particularly ICT tools, databases and systems that improve knowledge storage and sharing. The situation in Ghana is a reflection of what exists in many developing countries. Several scholars agree that part of the fundamental problem contributing to low rice yield, in developing countries, include limited technology use which allow efficient knowledge sharing practices in rice farming communities (Qureshi et al., 2018; Tariq et al., 2018; Wijitdechakul, 2018).

It is against this backdrop that this paper explores technologies are used by rice farmers for knowledge sharing in the Eastern Region of Ghana and suggest ways by which the use of these technologies can help enhance cultivation of rice not only in Ghana but in other developing countries.

1.1. Statement of the problem

Rice is an agricultural cereal produce belonging to the *oryza sativa* or *oryza glaberrima* grass species (Tariq et al., 2018). The parent species of rice (i.e. *oryza sativa*) is argued to be native to Asia and certain parts of Africa, but due to centuries of trade and exportation, rice has become commonplace in many countries worldwide (Tippe et al., 2017). In Ghana like most countries around the globe rice farming constitutes a critical part of Ghana's agricultural sector (Qureshi et al., 2018) and several efforts have been instituted

within the rice farming sector to improve rice farming practices and rice productivity. Amongst these are improved seed and soil technologies, subsidized fertilizers to rice farmers, and improved rice farming practices (Nimoh et al., 2012). However, low technological use,limited knowledge sharing limited knowledge and understanding on how best to promote the use of technology for knowledge sharing in rice farming communities have impeded rice productivity (Donkor et al., 2018; Tsinigo & Behrman, 2017). This article explores technologies use for knowledge sharing in three rice farming communities in Ghana and provide insights into how best to build competence for using technology to aid knowledge sharing among rice farmers in Ghana, and other developing countries.

2. Literature review

2.1. Knowledge sharing in rice farming

Knowledge sharing is an integral part of rice farming. Knowledge sharing is basically defined as the exchange of knowledge between individuals (Kaewchur & Phusavat, 2013). Prins et al. (2015) define knowledge sharing as the activities of transferring or disseminating knowledge from one person, group or organisation to another. Knowledge transfer refers to the sharing or dissemination of knowledge or knowledge from one part of an organisation to another (Andre et al., 2017). However, in both cases the definitions cohere around a common theme on making knowledge available to others to improve practices and productivity (Ting-Toomey & Dorjee, 2018). In this article, therefore, the two terms 'knowledge transfer' and 'knowledge sharing' are used interchangeably as suggested by researchers such as Andre et al. (2017) and Biconne (2014). Knowledge sharing thus becomes an activity through which knowledge (i.e., information, skills, or expertise) are exchanged among farmers within communities.

Knowledge transfer refers to the sharing or dissemination of knowledge or expertise from one part of an organisation to another (Andre et al., 2017; Kim et al, 2023). The terms knowledge sharing, and "knowledge transfer" have been used interchangeably in the literature. In this study knowledge sharing is defined as the practices involved in how critical information resources are communicated or exchanged among the rice farmers and other stakeholders involved in rice farming in the Region.

The factors that enable knowledge sharing have been categorised as individual-level factors, social and cultural factors organisational factors and technological factors (Cadger et al., 2016). Individual factors are qualities of individuals that make them more willing to share knowledge with others (Escobar et al., 2022; Rosenberry & Vicker, 2017). Amongst these individual factors that enable knowledge sharing are self-efficacy, effective communication skills, personal relationships and interpersonal trust, and motivation (Ortolani et al., 2017).

Organisational barriers constitute the factors at the level of organisations (in more formal sense) or communities of practice (in less formal sense) that impede or inhibit how individuals within the organisations share knowledge (Liu & Luo, 2014). Some of the organisational factors that act as barriers of knowledge sharing are financial constraints, lack of leadership and managerial support, hierarchy of work and organisational culture.

2.2. Enhancing the use of technology for knowledge sharing in rice farming

Technologies have proved to be extremely useful in the agricultural sector in general over the years.Technologies help farmers to grow crops in areas where they were not supposed to grow, but only through agricultural biotechnology (Abdulahi et al., 2014).The critical role of technology in agriculture is also extended into rice farming, particularly with regard to how knowledge is produced, stored and shared. Technology therefore influences knowledge sharing practices among rice farmers. It is argued that with the rapid development of ICTs has the most significant impact on knowledge management in general and knowledge sharing in particular, far more than any other factor (Bozzato et al., 2018). With the advent of ICT tools, the old inefficient methods of managing knowledge have been challenged (Bozzato et al., 2018).

Technologies provide a platform for collecting and codifying information and allows for distribution into decision support systems to improve practice (Otsuka, 2019). In recent times, new technologies and knowledge sharing systems have become ubiquitous in supporting information disseminations, not just in organizations, but also in communities (Nagothu et al., 2018). Technologies help to create knowledge repositories, create, share and transfer knowledge, provide technical infrastructure for communities of practice and knowledge network alliances. Technologies help in locating experts as sources of knowledge, and also help learning among virtual teams (Yan et al., 2015). These functionalities of technology offer several opportunities for sharing knowledge, both among rice farmers and in rice farming communities.

Technology helps the flow of explicit knowledge among rice farmers (Nagothu et al., 2018). It provides access to diverse substages of knowledge refineries that help to capture, organize, search and present content of information to render it meaningful and applicable to rice farming practice (Eberhardt & Vollrath, 2018). For this reason, Information Scientist argue that technology constitutes one of the three key pillars for codification of explicit knowledge, in addition to information warehouse and knowledge refinery (Yan et al., 2015). Technology also facilitates the transfer of knowledge among rice farmers (Yan et al., 2015), by facilitating contact between individual rice farmers or between rice farmer groups and other stakeholders in rice farmers so they can exchange information (Otsuka, 2019). Although Web 2.0 technologies such as Facebook, Wikis, Blogs, Google Docs, Flickr and Twitter is crucial for knowledge sharing, there is need to consider exploring Web 4.0 enabling digital technologies. Centobelli and Cerchione (2023) advocate digital technologies such as cloud-based technologies and artificial intelligence, are playing a key role in addressing disruptions can store and access vast amounts of data more easily, allowing employees to quickly find the information they need these technologies. In considering technologies to adopt issues of safety design of systems, their implementation, user perceptions, emerging roles and education technologies are crucial (Borycki & Kushniruk, 2021).

In the next subsection, different technological tools and systems for knowledge sharing are discussed.

2.3. Technologies for knowledge sharing in rice farming

There are several technologies that have potential for bringing effectiveness and efficiency in knowledge sharing among rice farmers. Knowledge-sharing technological tools discussed here are mobile phones, e-mail, skype, video conferencing and social media (e.g WhatsApp, twitter, Facebook, LinkedIn and IMO) and knowledge-sharing

systems. The ease use of technologies would increase sharing and integration of text, voice, data, images and video between rice farmers (Autio, 2020).

2.4. Mobile phones

Mobile phones are defined as telephones that have access to cellular radio systems that are used over a wide area without a physical connection to a network (Eraslan, 2013). There are three basic types of mobile due to its sophistication and functionalities (Yoon, 2013). These are cell phones, feature phones and smartphones. Cell phones are classical mobile phones that are usually used for the main purposes of calls and texts (Eraslan, 2013). Cell phones have fewer advanced features, focus on ease of use and are generally cheap (Ting-Toomey & Dorjee, 2018). Feature phones are built on the functionalities of cell phones by focusing on calls, texts and multimedia, and have full web browser and global positioning system (GPS) functions. Smartphones, on the other hand, are the most sophisticated in terms of their design and functionality (Rosenberry & Vicker, 2017). Smartphones function like miniature computers (Rosenberry & Vicker, 2017). They have an advanced operating system (OS), GPS, 4G internet speeds, and a smartphone is closer related to a computer than a cell phone (Ting-Toomey & Dorjee, 2018). Modern smartphones feature a highly responsive touchscreen, Wi-Fi connectivity, HD cameras and data streaming (Eraslan, 2013).

2.5. E-mail

Electronic mailing (e-mail for short) is defined as a technological method of sharing digital knowledge or messages via the internet or other computer networks (Garcia et al., 2018). In terms of knowledge sharing among rice farmers, e-mails are an important collaboration tool and channel for communicating knowledge amongst rice farmers (Kamarudin et al., 2015). The process of sending and receiving e-mails to and from colleague rice farmers results in the sharing of knowledge among themselves. E-mails are an effective means of sharing knowledge because the information contained in e-mails can be accessed and reused by rice farmers whenever the need arises (Chen et al., 2015). Garcia et al. (2018), for instance, indicate that archiving personal e-mails results in a repository of e-mail conversations, which can be useful for rice farmers for the purposes of managing and sharing knowledge.

2.6. Skype

Skype is a telecommunication application software that provides a platform for video chat and voice calls between technology-mediated communication devices such as computers, mobile devices, tablets, console and smartwatches via the internet (Ting-Toomey & Dorjee, 2018). For rice farmers, Skype can provide instant messaging services where rice farmers can send and received both text and video messages, including the exchange or sharing of digital documents that contain knowledge on rice farming (Rosenberry & Vicker, 2017). Skype also permits video conference calls where rice farmers can be connected to a single call simultaneously to discuss rice farming issues (Balaji et al., 2007). For these reasons, Skype constitutes a technological or digital platform that can enhance knowledge sharing among rice farmers.

2.7. Video conferencing

Technological advancement has offered the opportunity to hold virtual conferences involving different participants from different geographical locations. This is referred to as video conferencing. Video conferencing is therefore defined as a technologically mediated platform that provides broadcast of video and audio simultaneously to different users by means of digital communication tools (Holten et al., 2016). Video conferencing systems consist of various components that can be used by rice farmers to enhance their knowledge sharing. The components include an endpoint (e.g. computer), infrastructure (e.g. server which controls multipoint video conferencing sessions), peripheral equipment for the endpoint (e.g. microphones, cameras, etc.) and additional infrastructure expansion (e.g. instant messaging, telephony, recording and streaming) (Ting-Toomey & Dorjee, 2018). Video conferencing can help rice farmers in knowledge sharing in the form of virtual training and workshops.

2.8. Social media

Social media is argued to be the most revolutionized technology-mediated form of mass communication or mass media to aid knowledge sharing (Rosenberry & Vicker, 2017). Social media is defined as interactive computer-mediated technology that facilitates the creation and sharing of ideas, knowledge and other forms of expression of interests via virtual communities and networks (Eberechukwu & Queendarline, 2018; Taskin & Van Bunnen, 2015). Ting-Toomey and Dorjee (2018) also defined social media as a form of electronic communication through which users interact among people in which they create, freely share, exchange, and discuss information, ideas, personal messages and other content about each other and their lives using a multimedia mix of personal words, pictures, videos and audio, utilizing online platforms when they are connected to the internet.

Social media is an online interaction site where people interact to build, share and change their idea and comments regarding any information. It plays an activity role for rice farmers (Caers et al., 2013). In a way, it contains a wide range of online communications including blogs, company-sponsored discussion boards and chat rooms, consumer-to-consumer e-mail, consumer product or service ratings websites and forums, internet discussion boards and forums, moblogs and social media sites (SMSs). Examples of social media platforms include WhatsApp, Facebook, LinkedIn, Twitter, Imo, Telegram, Instagram, Snapchat, Facetime, Skype, YouTube, Messenger, Viber and MySpace. Social media platforms provide interactive features where individuals and groups meet to discuss and share ideas. Due to the interactive nature of social media, they can play a critical role in knowledge sharing among rice farmers. For example, various training programmes and workshops on rice farming can be delivered through social media to rice farmers across different geographic locations (Ting-Toomey & Dorjee, 2018).

2.9. Knowledge-sharing systems

2.9.1. Expertise locator systems

In rice production, expertise location is well positioned to provide rice farmers with the crucial support they need in achieving their knowledge-sharing and knowledge-management goals (Dzandu et al., 2014). The term ‘expertise location’ is defined as the

efficient processes involved in identifying human expertise, determining the status of critical resources and integrating the expertise within the organisational interaction processes (Hameed et al., 2018). In the context of rice farming, expertise location can be used for the maintenance of in-depth representations of skills, geographic positioning, availability and other indicators which are fundamental to the use of the expertise (Guo et al., 2015). Expertise location has become more relevant because of the need to generate and accumulate high intellectual capital for rice farmers (Dzandu et al., 2014). It has become the fundamental way of matching expertise and talents within communities of practice, such as rice farmers. An expertise location system helps in the process of connecting to the right rice farmers with the right knowledge at the right time (Dzandu et al., 2014). Expertise location includes activities such as the facilitation of mentoring programmes, the identification of knowledge gaps and the provision of both performance support and follow-up to formal training activities, all of which can enhance knowledge sharing among rice farmers (Hameed et al., 2018).

2.9.2. Knowledge repositories

Within the context of rice farming, knowledge repositories can become the means for retaining and sharing knowledge-based knowledge that is critical for rice farmers (Taskin & Van Bunnen, 2015). Knowledge repositories can allow rice farmers to connect individuals with knowledge and expertise globally through online platforms such as online discussion fora, online libraries and others (Chhim et al., 2017). Knowledge repositories can also provide rice farmers with a central location where people can digitally collect, contribute and share vital learning resources within both traditional and non-traditional work or learning environments (Bozzato et al., 2018). They serve as critical vehicle in just-in-time learning, enabling both post-training support and assessment for rice farmers (Taskin & Van Bunnen, 2015).

2.9.3. Best practice databases

Best practice databases can help rice farmers create a database to accumulate all indicators of best rice farming practices. Best practices are defined as benchmarks of excellence in terms of techniques and methods that are vetted through experience and research and are proved to reliably lead to desired results in rice production (Holten et al., 2016). Best practices are well fit for the knowledge rice farming context because the farmers get to define indicators and thresholds of best rice farming practices (Cheney & Lee Ashcraft, 2007). Having a best practices database, therefore, can help rice farmers keep track of their lessons learned to translate into best practices in increasing efficiency and productivity in rice farming (Taskin & Van Bunnen, 2015).

2.9.4. Lessons-learned databases

Obviously, lessons-learned databases are one of the best and most effective ways of sharing valuable explicit knowledge (Taskin & Van Bunnen, 2015). In terms of rice farming, lessons-learned databases are defined as knowledge-sharing systems or databases that contain knowledge gained from previous rice farming experience (Taskin & Van Bunnen, 2015). These previous experiences or lessons learned include knowledge of how colleagues have approached similar problems in rice farming in the past, and knowledge about efficient and effective methods that experienced rice farmers use to carry out their work (Holten et al., 2016). They involve sharing knowledge about what went well, what could be improved and how issues can be addressed before a task is

carried out again. Thus, lessons-learned databases are an effective technology for capturing knowledge in the form of lessons learned and making it available in a central location, where all rice farmers can have access to it (Holten et al., 2016).

2.9.5. Incident report database

Chhim et al. (2017) and Bozzato et al. (2018) all define an incident report database as a database that contains explicit knowledge of incidents that have occurred. In rice farming, an incident report database can help the rice farmers to document how they respond to incidents in their daily operations, and document what happened during the incident in the form of a report. This knowledge of incidents is often shared with other rice farmers through an incident report database (Taskin & Van Bunnen, 2015).

2.10. e-Learning capabilities in the environment of knowledge management

The integration of e-learning capabilities has revolutionized the field of knowledge management, enabling organizations to efficiently capture, share, and leverage knowledge resources. This write-up explores the intersection of e learning and knowledge management, highlighting the benefits and challenges associated with incorporating e-learning capabilities into knowledge management strategies. The analysis is supported by current academic references to ensure accuracy and relevance.

e-Learning offers numerous advantages in the context of knowledge management. Firstly, it provides a flexible and scalable platform for knowledge sharing and dissemination. According to Ahern and Dabirian (2020), e-learning tools and technologies enable organizations to capture tacit knowledge from experts, convert it into explicit knowledge, and disseminate it to a wider audience, regardless of geographical or temporal constraints. This facilitates continuous learning and upskilling across organizational boundaries. Secondly, e-learning enhances the accessibility and availability of knowledge resources. By leveraging digital platforms and multimedia content, organisations can store and deliver knowledge assets in various formats, such as videos, podcasts, and interactive modules. This accessibility empowers learners to engage with knowledge at their own pace and convenience. Learners can access information anytime, anywhere, fostering a culture of continuous learning and knowledge acquisition.

Furthermore, e-learning supports collaborative learning and knowledge creation. Online discussion forums, virtual classrooms, and social learning platforms enable learners to engage in peer-to-peer knowledge exchange, collaborative problem-solving, and co-creation of knowledge. This participatory aspect of e-learning facilitates the emergence of a collective intelligence, strengthening the knowledge management practices within organizations. Despite its benefits, incorporating e-learning capabilities into knowledge management strategies poses certain challenges. One of the primary concerns is the management of information overload.

The abundance of digital resources can lead to information overload, making it difficult for learners to navigate, filter, and extract relevant knowledge. According to Gao et al. (2021), effective information organization, metadata tagging, and intelligent search algorithms are essential to overcome this challenge. Another significant consideration is the need for continuous technological updates and maintenance.

The level of awareness of the use of technology by users will facilitate its adoption. Limaye et al. (2015) noted the need to maximize digital literacy in technology advancements in narrowing the digital divide. Digital literacy may take the form of e-

learning and training in the form of web-based learning and training, online learning, online training, web-based interaction (Mtega et al., 2014).

e-Learning platforms and tools rapidly evolve, and organizations must invest in the latest technologies, infrastructure, and support systems to ensure optimal performance. Failure to keep pace with technological advancements can hinder the effectiveness of e-learning initiatives within knowledge management practices.

e-Learning capabilities have transformed knowledge management by providing flexible, scalable, and collaborative platforms for knowledge sharing and dissemination. The benefits of e-learning include increased accessibility, enhanced knowledge availability, and the facilitation of collaborative learning.

However, challenges such as information overload and the need for continuous technological updates must be carefully addressed to maximize the effectiveness of e-learning in knowledge management. By leveraging e-learning capabilities and addressing these challenges, organizations can unlock the full potential of their knowledge resources, fostering a culture of continuous learning and innovation.

2.11. Theoretical framework

The article was underpinned by the socialization, externalization, combination and internalization (SECI) model to explain how technologies are used for knowledge sharing among the rice farmers. The SECI model was proposed by Nonaka et al. (1996) as a framework for explaining how knowledge is created, shared, transferred and used. The SECI model, since its development about two decades ago, has become an integral framework of knowledge creation, knowledge sharing and transfer (Hislop et al., 2018). The SECI model rests on the fundamental proposition of two fundamental types of knowledge, namely tacit knowledge and explicit knowledge. Based on these two types of knowledge, Nonaka et al. (1996) proposed four different ways through which various types of knowledge can be combined and converted simultaneously to show the complex ways in which knowledge is created and shared within organizational contexts.

The four ways are socialization, externalization, combination and internalization. The socialization (S) is the process of transferring tacit knowledge between individuals through observations and working with a mentor or a more skilled and knowledgeable worker (Daneshgar & Parirokh, 2007). With the socialization process, tacit knowledge is passed on from experienced to less-experienced workers through various means such as guidance, practice, imitation and observation. The externalization (E) is the process through which tacit knowledge is converted into explicit knowledge through documentation, verbalisation and so forth (Hislop et al., 2018). The combination (C) is the process of the mode of knowledge conversion involving the combination of different types of explicit knowledge (Nonaka et al, 1996). The internalization (I) is the process in which an individual internalizes explicit knowledge to create tacit knowledge (Hislop et al., 2018).

Of the four modes of knowledge conversion in the SECI model, the combination (C) mode really speaks to the role of technology in knowledge sharing and is therefore applied to explore the knowledge sharing technologies among rice farmers in the Eastern Region of Ghana. Within the SECI model, the combination is the mode of knowledge conversion involving the combination of different types of explicit knowledge (Nonaka et al., 1996). This involves the ways in which codified knowledge sources (e.g. documents and web pages) are combined to create new knowledge for use within an organisation (Daneshgar & Pariokh, 2007). Creative use of technological tools and databases to get

business reports, sorting, adding and categorizing are some examples of the combination process. In other words, the combination is a mode of knowledge conversion which involves the combining of different types of technology-mediated explicit knowledge (Hislop et al., 2018).

The combination happens when people exchange knowledge via documents, telephone, WhatsApp, Facebook and meetings. Knowledge transfer through the use of technologies and tools such as e-mail, intranet, groupware, distribution of printed documents and CD-ROMs are examples of how ICT has also greatly enabled this type of knowledge sharing. This new knowledge will normally be a valuable source for decision making and planning for rice farmers in the Eastern Region (Daneshgar & Pariokh, 2007). The combination is argued to be the simplest form of knowledge sharing (Hislop et al., 2018; Nonaka et al., 2000).

The combination (C) component of the SECI model is significant to this article because it provides an adequate framework for investigating technologies used for knowledge sharing among rice farmers in Eastern Region of Ghana. In the first place, the combination provides a framework for examining how the rice farmers use technologies to create and convert knowledge within their rice farming activities. This helps to understand how the rice farmers continuously create, use and reuse knowledge in a continuous and dynamic manner (Hislop et al., 2018). Apart from helping to explain how the rice farmers create and convert knowledge, the combination also provides a framework for understanding how the knowledge is shared and transferred among the rice farmers using technology-mediated platforms. This helps to uncover the different kinds of technologies and tools in knowledge sharing and how technology use can be enhanced among the farmers.

3. Method

The study was underpinned by pragmatism where a concurrent triangulation mixed method design was collected and analysed both quantitative and qualitative data simultaneously. The population of consisted of smallholder's rice farmers, farm managers and agricultural/extension officers in the Kpong, Akuse and Asutsuare communities in the Eastern Region of Ghana. Data was gathered using cross-sectional survey for the quantitative component and in-depth interviews for the qualitative component.

A total of 110 participants were used for the study, comprising 101 survey respondents and nine interview participants. The 101 survey respondents were selected using convenience sampling. For those who could read and write, the questionnaires were distributed to them in hardcopy to be responded to and returned. For those who could not read and write, the researcher-administered technique was used where the researcher assisted them by reading and interpreting statements to them for them to choose. The demographic characteristics of the 101 survey respondents are provided on Table 1.

Among the 101 survey respondents, there were more males (70.9%) than females (29.8%). Their ages ranged between 19 – 62 years. Majority of them had up to high school education (70.2%).

The instrument (questionnaire) examined three elements of technologies – tools, social media and technological systems. Apart from the close-ended items used, spaces were also provided for respondents to list other technologies they use but not captured in the questionnaire. The questionnaire was pilot tested among a sample of nine respondents, and the test-retest procedure was used to test the reliability with Pearson r test, with the

help of analyzed SPSS software. The pilot test yielded high test-retest reliabilities for tools ($r = 0.88$, $p < .001$), social media ($r = 0.91$, $p < .001$) and technological systems ($r = 0.91$, $p < .001$). After gathering the main data, the reliability was examined using Cronbach alpha and the responses were analyzed using frequencies and percentages.

Table 1
Demographic characteristics of survey respondents

Demographic	Categories	Frequency	Percentage
Gender	Male	71	70.2%
	Female	30	29.8%
Age	Below 20 years	2	1.9%
	21 – 30 years	9	8.9%
	31 – 40 years	30	29.7%
	41 – 50 years	20	19.8%
	51 – 60 years	34	33.7%
	60+ years	6	5.9%
Educational level	No school	2	1.9%
	Basic school	16	15.8%
	High school	71	70.2%
	Tertiary	12	11.8%

The nine interview participants comprised of three (3) smallholder's rice farmers who were conveniently selected, and three farm managers and three agricultural/extension officers who were purposively selected from the three districts in the Eastern region. All the interviews were conducted individually, at time and venue decided by the participants. Small sample size was selected for the qualitative phase because Creswell (2014) asserted that fewer participants are needed for researchers to make in-depth assessments to the perspective of knowledge sharing technologies used by rice farmers in the Eastern Region of Ghana. (Kommey, 2020).

In the qualitative data, in-depth individual interviews were conducted using a semi-structured interview guide. Sample questions in the guide included; What type of technologies are used for knowledge sharing among the rice farmers? What knowledge sharing systems you are familiar with? What type of social media you are familiar with? What kind knowledge sharing tool you are comfortable with? The interview guide opened conversations into issues addressing technologies for knowledge sharing. The individual interviews (from the farm managers, extension officers and rice farmers) were analyzed using content analysis. Trustworthiness was ensured how dependability, confirmability, credibility and transferability were used in the article (Lincoln & Guba, 1985; Silverman, 2015). For the purpose of confidentiality and anonymity of interviewees' identities, the researcher used a serial code to represent the interview participants as provided on Table 2.

The farmer manager from the Akuse District was coded as IFMAD-1, the farmer manager from the Kpong District as IFMKD-2, and the farmer manager from the Asutruare District as IFMAD-3. The rice farmer from the Akuse District was coded as IFAD-4, the rice farmer from the Kpong District as IFKD-5, and the rice farmer from the Asutruare District as IFAD-6. The extension officer from the Akuse District was coded as IAOAD-7, the extension officer from the Kpong District as IAOKD-8, and the extension officer from the Asutruare District as IAOAD-9.

Table 2
Demographic knowledge of interview participants

Participants' Code	Status	Gender	Age	Education
IFMAD-1	Farm Manager	Male	53 years	Master's Degree
IFMKD-2	Farm Manager	Male	50 years	Master's Degree
IFMAD-3	Farm Manager	Male	55 years	Master's Degree
IFAD-4	Farmer	Female	57 years	Middle School
IFKD-5	Farmer	Female	44 years	No Education
IFAD-6	Farmer	Female	46 years	No Education
IAOAD-7	Agric Officer	Male	60 years	Diploma
IAOKD-8	Agric Officer	Male	58 years	Bachelor's Degree
IAOAD-9	Agric Officer	Male	42 years	Bachelor's Degree

4. Findings

The findings from the quantitative data are presented first, followed by findings from the qualitative data.

4.1. Quantitative findings

Tools used for knowledge sharing were first examined among the rice farmers. The findings are provided on Table 3.

Table 3
Tools used for knowledge sharing among farmers

Tools	Yes in %	No in %	Somehow in %
Magazines	88.2	8.2	3.6
Electronic databases	75.5	9.1	15.5
Expertise locator system	70.0	22.7	7.3
E-mail	64.5	10.9	24.5
Extranet	58.2	35.5	6.4
Intranet	41.6	47.3	10.9
Video conferencing	19.1	67.3	13.6
Skype	13.6	72.7	13.6
Blogs	11.8	74.5	13.6

Findings showed that magazines, electronic databases and the expertise locator system were the main tools frequently used for knowledge sharing among the rice farmers. As shown in Table 3, the majority of the respondents suggested that the technological way for the knowledge shared among farmers with a recorded "yes" was with magazines, with 88.2%, followed by electronic databases, with 75.5%, the expertise locator system, with 70.0%, and e-mail, with 64.5%, respectively. However, it was observed that blogs as a technological tool for knowledge sharing yielded 11.8% for "yes", 74.5% for "no" and 13.6% for "somehow". Overall, Skype and video conferencing recorded the least use, with the lowest value of scores.

Some of the other tools that emerged from the open-ended questions revealed the following:

"Sometimes we share knowledge with them by sending them letters" (farm manager).

"We also share knowledge using letters and memos" (male rice farmer).

"We use Intranet for our day-to-day activities" (male rice farmer).

"We also upload documents on rice production and farming from the Intranet or SharePoint" (farm manager).

The next subsection presents findings on social media platforms used for knowledge sharing among the farmers. The findings on the technologies used for knowledge sharing among the rice farmers are presented in this subsection. The results are provided in Table 4.

Table 4
Social media platforms used for knowledge sharing

Social media	Yes in %	No in %	Somehow in %
WhatsApp	91.8	3.6	4.5
Twitter	25.5	60.9	13.6
Facebook	23.6	62.7	13.6
LinkedIn	20.9	65.5	13.6
Imo	10.0	65.5	24.5
Instagram	8.2	69.1	22.7

Findings showed that, generally, the use of social media in knowledge sharing among the rice farmers was very low. The WhatsApp platform came up as the dominant technology platform that is mostly used. All the other platforms recorded extremely low "yes" responses and extremely high "no" responses. As shown in Table 4, the majority of the respondents showed that the social media platform for the knowledge sharing among farmers was through WhatsApp (91.8%). Other social media platforms used such as Twitter (25.5%), Facebook (23.6%), LinkedIn (20.9%), IMO (10%) and Instagram (8.2%) were used less frequently in sharing knowledge among the rice farmers.

Some of the other technologies provided by the respondents in the open-ended question are revealed as follows:

"Sometimes we get some knowledge from research-gate and we share with the rice farmers" (farm manager).

"Snapchat too can be used to share knowledge among the farmers" (farm manager).

"Technologies are used effectively for knowledge sharing" (female rice farmer).

The next section presents findings on the technological systems used for knowledge sharing among the rice farmers. The results are provided in Table 5.

Findings showed the average use of technological systems for knowledge among the rice farmers. As shown on Table 5, expertise locator systems (67.3%), incident report databases (64.4%) and best practices databases (59.1%) recorded the average use in knowledge sharing among the rice farmers. Lessons-learned databases (39.1%) and alert systems (38.2%) were the least used for knowledge sharing among the rice farmers.

Table 5
Systems used for knowledge sharing among farmers

Technological systems	Yes in %	No in %	Somehow in %
Expertise locator systems	67.3	30.0	2.7
Incident report databases	64.4	19.1	14.5
Best practices databases	59.1	29.1	11.8
Lessons-learned databases	39.1	37.3	23.6
Alert systems	38.2	35.5	26.4

Some of the other systems of knowledge sharing indicated by respondents in the open-ended question revealed the following:

> *"Rice farmers use knowledge bank and to learn quickly thereby improving rice production"* (male rice farmer).
>
> *"Knowledge sharing portals are also used for sharing knowledge among the rice farmers"* (farm manager).
>
> *"Rice farmers should be trained to use electronic resources effectively"* (male rice farmer) (Kommey, 2020).

4.2. Qualitative findings

This subsection presents the qualitative findings of the technologies used for knowledge sharing among farmers. Findings from the participants suggested that WhatsApp, community radio announcements, film shows, and instant messages were the technological means by which knowledge was shared to the rice farmers.

Manager, Kpong farms – IFMKD-2 – said:

> *Knowledge sharing is the means of exchange of knowledge or knowledge via knowledge management systems such as electronic mail, skype, telephone. Besides, it is also a way to share insights and experiences.*

IFMAD-3 said:

> *During conference or workshops, we advise the farmers to form WhatsApp groups per district or zonal areas of proximity, because disseminating knowledge to them on such platform is better than calling each of them separately.*

The researcher asked what happens if a farmer's phone did not support WhatsApp or if that farmer is using a 'Yam phone'? ('Yam phone' is terminology in Ghana which is used to refer to analogue phones or phones that do not support social media platforms.)

Findings from the interviewees indicated that almost all the rice farmers within the communities use smartphones. Even though not all of them know how to use all the functionalities of the smartphones, they still by it because it is fanciful:

IAOAD-7, for instance, said:

> *In our daily engagements with them [the rice farmers], we realize that they are all using smartphones. Everybody wants to have a smartphone these days, even if they cannot use all the functions of the phone. So, they all have smartphones, and it is one area we are still thinking of exploring.*

IFKD-5, who himself is a rice farmer, reiterated that point:

> *This is my phone. My son bought it for me because everybody was having one and I was not. So, my son bought one for me. It can do everything like play songs and videos. If they show us how to use it well, we can use to send information to our colleagues because we all have phones like that.*

There have been attempts to use the smartphones to share information, but there are still challenges, since some rice farmers still call for information after the same information has been put on a WhatsApp platform created:

IFMKD-2 added:

> *Although there is an existing WhatsApp group, messages sent to that group are also followed by calls or asking the agricultural officers to inform them when they visit them on their farms.*

When the issue was probed among the rice farmers, the consensus was that their lower educational level limits how well they engage with information on WhatsApp platforms:

Interviewer:

> *The managers and officers are saying they always send a message on your WhatsApp platform. What do you say to that?*

IFAD-6 said:

> *It's true! But some of us are not ICT inclined to know or read each message. Again, extension officers come to inform us of such messages but always come a week early (IFAD-6).*

With respect to the WhatsApp theme, IFMAD-1, IFAD-4, IFAD-6, IAOAD-7, IAOKD-8 and IAOAD-9 all commented that WhatsApp messages are sent to the group platform. However, IAOAD-7 again said that, aside from the WhatsApp message, instant messages are normally sent by the officers before the programme's due date.

> *Yes, I have received such a message before that was when we were going for the Planting for Food and Job workshop in the regional capital, Koforidua (IFAD-4).*

IAOKD-8 posited:

> *We have the biodata for all farmers in the district including other emergency lines of contact. We the officers in the district do call them before we even embark on our journey to their farms. The calls are effectively done through WhatsApp platform messaging.*

Aside from the instant messages and WhatsApp, IFMAD-I said that they also communicate through the community radio. The interviewer asked about the dissemination of knowledge on how to implement certain mechanisms.

IFMAD-1 said:

> *Such activities are normally done when we are having a workshop. We first show a video of such activities to them before giving them a hard booklet.*

Probing, the researchers asked: "So what happens to the modern technological way of disseminating knowledge like IMO, Skype, Facebook and the rest?"

IFMAD-1 replied:

Ahhh!!!! These systems are done between the managers and extension officers.

IFMAD-2 said:

There are network challenges in some of the farms and most of the farmers, sorry to say, are not ICT inclined to know these systems of communication. Even the easy one like a phone call and replying sent messages become a challenge.

IFKD-5 attested to the following fact:

Messages are communicated to them on regular bases but how to access them becomes a problem. My farm is located about 40 miles away from the district capital. Coupled to the location is the poor network and bad road network makes it difficult for the extension officers to disseminate knowledge to us regularly. For the messages they send, but how to access them becomes the challenge.

IAOAD-7 shared the following:

The knowledge is distributed to us and it is sent to them. This is because we are closer to the farmers, and we work with them on a day-to-day basis.

The respondents suggested that group WhatsApp messages, instant messages, community radio broadcasts and video shows by way of presentation during the workshops were more effective technological ways for sharing knowledge than other means like Facebook, Skype, e-mail and face-to-face time due to the unavailability of good telecommunication network support.

5. Discussion

The qualitative and quantitative findings from the article have showed that some technologies are being used for knowledge sharing among the rice farmers. The qualitative data established further that the use of smartphones is predominant among the rice farmers. However, the use of technology in knowledge sharing among the rice farming was generally low. The dominant tools used for knowledge sharing were magazines, electronic databases and the expertise locator system. The dominant tools used for knowledge sharing among the rice farmers suggest there was an emphasis on expertise or experience. Expertise locator systems fundamentally provide a platform to accumulate high intellectual capital by leveraging existing skills, knowledge and experience to boost productivity (Hameed et al., 2018). These findings were in line with those of Dzandu et al. (2014), reiterating that the expertise locator system helps to connect the right rice farmers with the right knowledge at the right time. This means that the rice farmers have systems that allow them to connect the rice farmers to a local and context-based experience within a reasonable time.

Tools such as the extranet, internet and e-mails were moderately used by the rice farmers for knowledge sharing. The tools that were used the least were video conferencing, Skype and blogs. Apart from these, there were other tools identified such as letters, memos and other documents, which are all used for knowledge sharing (Chhim et al., 2017). These tools are mainly functional technologies that allow for easily accessing and sharing of information. Blogs, for instance, provide technological means of writing stories of individuals' experiences where others can access knowledge (Rosenberry & Vicker, 2017). These findings are in line with Chhim et al. (2017) who reported that rice farmers can create 'multi-author blogs' (MABs), where posts are written by a large number of rice farmers covering varieties of topics in rice farming.

Skype and video conferencing also help rice farmers to hold virtual meetings where knowledge can be shared. Skype, in particular, has features that allow for video conferencing where rice farmers are able to join virtual meeting platforms to discuss rice farming issues (Ting-Toomey & Dorjee, 2018).

The article showed that the main social media platform used for knowledge sharing was WhatsApp. The least used technologies were Twitter, Facebook, LinkedIn, Imo and Instagram. Other technologies identified included ResearchGate and Snapchat. Findings from the quantitative data coincided with the qualitative data, which showed that the social media platform identified from the qualitative data for knowledge sharing included: WhatsApp, instant messages, electronic mail, and telephone, IMO, Skype and Facebook. These are mainly social media platforms that have gained popularity in the last decade. The social media platform offers the rice farmers an opportunity for accessing and sharing knowledge in print, pictures or images, and in video formats. This is because social media platforms provide interactive features and allow individuals to discuss and share ideas anytime and anywhere without physical or time boundaries (Holten et al., 2016).

However, WhatsApp was the most frequently used social media platform for knowledge sharing among the rice farmers. This is a reflection of the social media use among the general Ghanaian population. In Ghana, for instance, research suggests that WhatsApp is the most widely used social media platform among the general population, followed by Facebook (Bernard & Dzandza, 2018). Among the rice farmers, WhatsApp and Facebook were used to both access information and monitor news updates. This may explain why WhatsApp was indicated by the rice farmers as their most used technology for knowledge sharing. The other social media platforms (e.g. Twitter, LinkedIn, Instagram and others) were used mainly by individuals with the appreciably high level of education. However, ResearchGate was mostly used by the academic community for disseminating research knowledge (Taskin & Van Bunnen, 2015). This may explain why ResearchGate was the least used among the rice farmers.

The article showed that knowledge-sharing systems were moderately used for knowledge sharing among the rice farmers, including systems such as expertise locator systems, incident report databases and best practice databases. The least used systems were the lesson-learned database and alert systems. Apart from these, other systems identified included the knowledge bank, knowledge sharing portals and electronic resources. Knowledge sharing systems perform a critical role in knowledge sharing and knowledge management (Hameed et al., 2018). More specifically, knowledge sharing systems support the process through which explicit or tacit knowledge is communicated to other individuals (Bozzato et al., 2018). They also help in storing knowledge for future use. For this purpose, knowledge-sharing systems were also referred to as knowledge repositories (Holten et al., 2016).

These critical roles notwithstanding, knowledge-sharing systems were not used much among the rice farmers. The reason could be the fundamental technological challenges that are experienced in the setting where the study was conducted. Technological penetration, in terms of structures that support technological architecture, was extremely low in the communities. Per the location of the farm sites, there was less technological advancement in the villages where the farms were situated. The farming communities do not have the connection to high-speed internet to support 3G and 4G internet services to enhance access to knowledge-sharing applications like IMO, Instagram and Facebook. Apart from the structural technological challenges, educational levels within the study settings are also low, particularly among farmers. The rice farmers

have low levels of education, and because of that, most of them are not used to the modern technologies for knowledge sharing. These structural challenges account for the limited use of technological systems for knowledge sharing. The farmers were therefore left to depend on community-based engagement technologies such as community radio announcements and film shows for knowledge sharing, as reflected in the qualitative data of the article.

The study contributes to knowledge by being the first to empirically establish the context of the use of technologies in knowledge sharing practices among rice farmers in Ghana. Research on knowledge sharing technologies among rice farmers are dominated by studies from high income countries. Research in African contexts is largely non-existent. The study therefore contributes expands knowledge by providing empirical evidence on knowledge sharing technologies among rice farmers in Ghana.

6. Recommendation

The article recommends that strategies for encouraging technological use should start with what the rice farmers already have. For instance, it was established in the qualitative data that most of the rice farmers use smartphones. Smartphones support social media, and audio and video functionalities, which the rice farmers can be encouraged to use in sharing information among themselves.

The article further recommends that more audio and video-based technologies and apps, preferably in the local language, be used. For instance, information can be recorded using voice recording in local languages and sent to the rice farmers. Information can also be represented with visual images for the rice farmers to easily see and understand. This is because the educational levels of the rice farmers were generally low, with the majority not having a tertiary education. Using audio and video technologies in local language would make knowledge easily accessed and shared by the rice farmers among themselves to encourage more horizontal ways of ensuring knowledge sharing.

In addition, the article recommends further that there should be more public education on using technologies to aid knowledge sharing among the rice farmers. This is because the findings suggest there is some form of use of all technologies for sharing knowledge, even though their use was limited. Educating the rice farmers on what each of the different technologies are and what their uses are would help them to become familiar with the technologies and encourage them to use. Such public education would expose the rice farmers to the other forms of technologies (such as knowledge-sharing systems, databases and video conferencing technologies) so that they would develop awareness of them and be encouraged to use them.

Lastly but more critically, the technological competence of the rice farmers needs to be built purposefully. This requires organizing training workshops for the rice farmers and teaching critical information literacy skills. Such skills would help the rice farmers to know how to use different forms technologies to access and share information among themselves.

7. Conclusions

This article explored technologies that are used for knowledge sharing among the rice farmers in the Eastern Region of Ghana, and how technology use among the farmers for knowledge sharing can be enhanced. Rice farmers stand the advantage of benefitting

immensely from the opportunities offered by online or e-learning through exchange of knowledge. Such acquired innovations and skills, when well decoded and processed offers the farmer the advanced skills and know-how needed to promote and bring about positive strides now and thereafter. Equally important it is the ability it offers to build these into a major resource capable of being retained, stored for permanent preservation and for dissemination. Emerging technological tools have enhanced and improved rice farming in general. It also provides innovative insights, solutions, cutting edge and long-standing digital tools in knowledge sharing for rice farming in the digital world.

Findings from both quantitative and qualitative data showed that rice farmers were already engaging with technological tools, even though their functional use was limited. The findings have implications for devising strategic and innovative ways of encouraging the use of technologies for knowledge sharing among rice farmers. Building technological competence of the rice farmers is critical in achieving high use of technologies for knowledge sharing. Finally, information literacy skills as fundamental in achieving technological competence in knowledge sharing among the rice farmers.

Author Statement

The authors declare that there is no conflict of interest.

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