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MOBILE PHONE-ASSISTED AGRICULTURAL EXTENSION SERVICES: USER COMPETENCY AND USAGE FREQUENCY IN EASTERN GHANA

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ABSTRACT

Adoption studies have mainly focused on econometric and quantitative modelling that usually assume smallholder farmers competently adopt agricultural technologies. This study provides novel insights on user competency and frequency of usage of mobile telephony for agricultural extension services among smallholder farmers and agricultural extension agents (AEAs) and key factors that impede the adoption process. The study examined users' competencies and mobile phone usage frequency for access and delivery of agricultural extension services in Eastern Ghana. A multi-stage sampling procedure was used to select 95 AEAs and 330 smallholder farmers in five districts of the Eastern region of Ghana and data were collected through semi-structured interviews. Descriptive statistics, Pearson correlation and regression analyses were performed to analyse the data. Results showed substantial differences between AEAs and smallholder farmers' competency in the use of mobile phones for agricultural extension services. Socio-demographic characteristics of smallholder farmers and AEAs correlated with usage frequency of mobile phones for access to extension services and delivery. Educational level, amount of weekly expenditure of money on mobile phone use, mobile phone network quality, income level, and age of both AEAs and smallholder farmers had positive and significant correlations with frequency of usage of mobile phones. User competency differentially impacts the frequency of mobile phone use in agricultural extension services between AEAs and smallholders. High call tariffs and access to recharge cards are major challenges in using mobile phones for agricultural extension in the study areas. The study shows components of the adoption theory of compatibility, and complexity where an innovation fits within the socio-cultural framework and perceived difficulty of use. Thus, the frequent use of voice calls is indicative of early stages of the diffusion process and may diversify into other applications in the future. Farmer-based organisations should be resourced to support training of farmers to use mobile phones to improve access to agricultural information dissemination. Integrating voice-based agricultural information services (IVRs) into the current SMS-based agricultural extension services in Ghana could potentially boost extension service delivery to smallholder farmers in the Eastern region and across the country. The Ministry of Food and Agriculture may partner with key stakeholders and mobile service providers to offer hands-on capacity building to smallholder farmers and AEAs in video calling/conferencing, multimedia service, and social media to enhance their competencies for improved agricultural extension services.

Key words: Agricultural extension agents, agritech, e-extension, mobile phone application, smallholder farmers, Ghana

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INTRODUCTION

Through various information communication technologies (ICTs), the evolution of traditional societies worldwide into information societies and relationships in the 21st century has significantly changed [1, 2]. Use of modern ICTs, especially mobile phones have greatly reduced the usually high costs of providing information via face-to-face interaction that is typically impaired by poor agricultural roads and access to prompt information by smallholder farmers and agricultural extension workers [1, 2]. The agriculture sector contributes approximately 23 % of Ghana's GDP and employs approximately 58 % of the economically-active population [3]. Yet, agricultural production is stagnated due to extension services, which adds to the loss in yield and poor agricultural productivity [4]. Furthermore, unsuccessful technology transfer at the farm level is caused in part by insufficient extension services and limited access to relevant information [4,5]. In 2003, mobile telephony for extension services was introduced by the Ministry of Food and Agriculture (MoFA) to improve the distribution of relevant agri-information for smallholder farmers in specific geographical areas and cropping systems in Ghana [3, 5].

The largest mobile subscriber base in Africa is in Ghana, Kenya, Nigeria and South Africa [1]. The global system for mobile communications (GSMC) has rated Ghana as a leader in mobile telephony in Africa. The subscription for mobile phones has grown from 212, 548 in 2000 to 284, 981 in 2012 with 30,629,604 mobile phones connecting in the world [6]. Thus, given their limiting resource conditions, mobile phone usage among smallholder farmers has been growing in tandem with the increase of telecommunication coverage. Studies have shown that mobile phone usage among smallholders increases income [7], lowers production costs [8, 9], increases productivity [10] and enhances communication with agri-food suppliers/farmers and consumers [11]. Furthermore, mobile innovation has lowered hunger and improved rural living standards [1, 12-17]. Alexander *et al.* [18], however, reported that both the percentage of smallholders and AEAs with access to relevant communication services as well as the level of, and the use of relevant information in the agriculture sector in Ghana are limited, and that the Eastern region is no exception.

Innovation diffusion theory explains how innovation is embraced by a social community, resulting in innovation being a part of the current social structure. In the theory, Rogers [19] proposed that diffusion is the mechanism through which a concept, event, or new innovation is transmitted to members of a social structure over a period of time through well-defined channels. This study was therefore, conducted to answer the following questions: (i) What is the user competency level and frequency of mobile phone usage in access and delivery of agricultural extension services? And (ii) Are there differences between smallholder farmers and Agricultural Extension Agents (AEAs) in user competency and frequency of mobile phone usage in access and delivery of agricultural extension service in the varied agro-ecology and farming systems of the Eastern Region of Ghana? The findings of the study have policy implications for investment mobilisation required to build a more robust infrastructural base to enhance mobile phone usage among smallholder farmers and AEAs. The findings of the study are also crucial in designing appropriate training package to build

the capacity of AEAs and Farmer-based organisations (FBOs) in the use of mobile phones to support agricultural extension delivery in Ghana. In the context of this study, user competency (ies) refers to the abilities, skills and behaviours of AEAs/smallholder farmers to use cell or mobile phones competently or to be prepared to learn and develop and/or enhance their access to or supply of agricultural information. We hypothesised that there is no substantial gap between user competency in mobile phone usage by farmers and AEAs for agricultural extension. Hypotheses were tested at 0.05 alpha as follows.

Null hypothesis, ***Ho:*** *There is no substantial difference between user competency in mobile phone usage for agricultural extension services access and delivery by farmers and AEAs.*

Alternative hypothesis, ***Ha:*** *There is substantial difference between user competency in mobile phone usage for agricultural extension services access and delivery by farmers and AEAs.*

METHODOLOGY

Study design

Descriptive research design was used. AEAs and smallholder farmers' competency levels and frequency of usage of mobile phones to access and deliver agricultural extension services in Eastern Ghana were evaluated.

Study area

The Eastern region of Ghana constitutes 8.1 % of the total land area of Ghana; the sixth largest land area sharing common borders with the regions of Ashanti, Greater Accra, Volta, Central and Brong, respectively (Figure 1). The total population of the region is 2, 106, 069 [8]. The population is made up of 49.2 % males and 50.8 % females, giving a gender ratio of 96.8 males to 100 females [8]. The region is inhabited by the following major ethnic groups: Akan (52.1 %), Ga-Dangme (18.9 %), Ewe (15.9 %) and Guan (7.2 %). Mobile phone ownership in the region is estimated at 820,517 [8] with smallholder farming as a major occupation. The study was conducted in the following five districts of the region: Akuapem south, Fanteakwa, Kwahu South, Upper Manya and Yilo Krobo districts. The populations of the districts vary from 37,501 with the Akuapim South district to 108,614 with the Fanteakwa district. Mobile phone ownership in the districts also ranged from 6,590 in the Upper Manya Krobo district to 45,451 in the Akuapim South district [8, 9]. Major socio-economic activities of the five districts include: vegetable production, cattle, and fresh water fishing in the Upper Manya district, and tree crop farming (cocoa, oil palm and mangoes), forestry, cassava, plantain, vegetables, and livestock (sheep, cattle and goats) in the Fanteakwa district.

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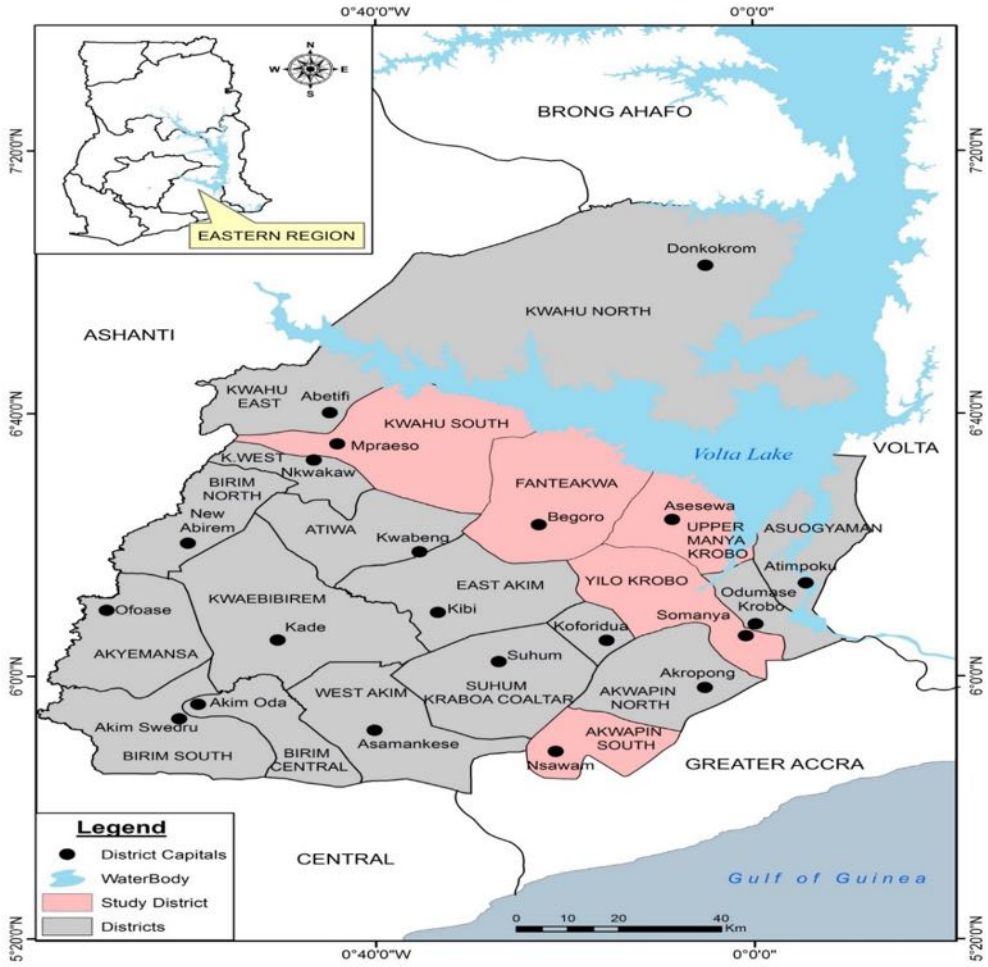

Figure 1: Map of Eastern region of Ghana showing study districts [8]

Sample size and sampling technique

All agricultural extension agents (AEAs) and registered smallholder farmers working in the five districts mentioned above were the target population for this study (Figure 1). Multi-stage sampling and simple random sampling were employed. Close- and open-ended questionnaires were used for data collection from 95 AEAs and 330 smallholder farmers. Twenty-six (26) communities in the study area were randomly selected from Fanteakwa, Kwahu South, Yilo Krobo, Akuapim South and Upper Manya districts. All the 95 AEAs operating in the selected districts as provided by the district directors of MoFA were used in the study. In a sample framework to select smallholder farmers, a list of all registered smallholders working with the 95 AEAs was compiled. A simple random proportionate sampling technique was used to select 330 farmers out of the 2393 farmers with 95 AEAs following Krejcie and Morgan [20], (Table 1). Selected experts from the Agricultural Extension Department, University of Cape Coast validated data collection instrument. The questionnaire was subsequently tested in fields between 20 smallholder farmers and 10 AEAs from Suhum East district, which was subsequently excluded from the study.

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Data collection and analyses

Five AEAs (who were not part of the respondents) were selected and trained from the five districts to assist in the data collection. Semi-structured questionnaires and interviews were administered to the AEAs and smallholder farmers simultaneously during the district monthly meetings of the extension officers. In the second phase, farmers were contacted on phones and AEAs assigned in the district scheduled a meeting with them in their houses or on their farms. Five (5) enumerators who knew the territory, culture, and spoke the local dialects were formally trained to assist in the data collection. Twelve (12) items were constructed to measure user competency levels of smallholder farmers and AEAs whilst frequency of mobile phone usage was measured as the number of times smallholder farmers or AEAs use mobile phones to access or deliver agricultural information. Correlation (s) between usage frequency of mobile phones and background characteristics of farmers and AEAs were estimated. The overall frequency of usage of mobile phone was estimated as composite mean (Y) from voice calls, short messages sent/received, accessing internet and e-mails, WhatsApp, Facebook (social media), multimedia service, video calling or conferencing and listening to radio on mobile phones. Socio-demographic characteristics were coded and computed (Table 2).

To determine the key factors that influence frequency of usage of mobile phones, multiple linear regression analysis was performed using key socio-economic/demographic characteristics for both smallholder farmers and AEAs (Table 6). The data collected were cleaned, coded, and analysed with IBM-SPSS (ver. 21). Data were analysed using descriptive statistics (frequency, percentages, means and standard deviation). Independent t-test, regression and correlation analyses were performed to determine the differences between AEAs and smallholder farmers' competencies and frequency of usage of mobile phone in disseminating and accessing agricultural information.

RESULTS AND DISCUSSION

Socio-demographic characteristics of smallholder farmers and AEAs

Mobile telephony has become a necessary part of our daily culture and lifestyle [1, 22]. It is an indispensable portable handheld gadget in most professional setup including smallholder farming and agricultural extension. Therefore, this study was conducted to assess how user competency and frequency of usage dictates the adoption and effective utilisation of mobile phones in agricultural extension. There were more male AEAs (89 %) and farmers (76.8 %) than their female counterparts (11 % AEAs and 23.2 % smallholder farmers), respectively (Table 2). This suggests male dominance in agriculture in terms of extension delivery and participation by smallholder farmers (Table 2). According to Owusu *et al*. [21], Tata & McNamara [22], agriculture is still a male-dominated venture in Ghana, particularly as the sector is family-led, where the head of the household often leads decision-making. Furthermore, several studies [23-26] indicate that, men dominate extension services as they have better social capital with direct links for exchange of information and learning than their female counterparts. Although, smallholder women farmers constitute the largest agricultural labour force in Ghana, and produce roughly 70 % of the national food supply [21], they

are the least served by extension services and are disadvantaged as a result of limited access to resources, restricted decision-making power, lower education level, and limited access to agricultural inputs and credits [24].

The mean household size of smallholder farmers and AEAs was 6 and 5, respectively. The mean and standard deviation of working experience (in years) of farmers were (M = 18.45, SD = 10.31) and AEAs (M = 18.45, SD = 9.36), with most smallholder farmers cultivating five hectares or less (≤ 5 ha) of land. From our findings, smallholder farmers with larger household sizes competently use mobile phones through the help of their children, especially if they are educated (Table 2). This corroborates report of Okello *et al.* [27] that, smallholder farmers with educated children are advantaged to use mobile phones for accessing relevant agricultural information. Common among these basic uses include '*how to dial and receive calls, store and retrieve messages, send and receive messages*' through the assistance and direction of their children. Most of the smallholders and the AEAs had over 6 - 10 years of mobile phone usage experience in different ways (Table 2). Ibrahim *et al*. [11] argued that, the more experienced AEAs and smallholder farmers are, the more they are exposed to sources and channels of relevant information. According to MoFA [5, 26], majority of Ghanaian smallholder farmers engage in subsistence farming using traditional methods and low technologies which debar them from cultivating sizeable hectares of land. The smallholder farmers who cultivate over 6 hectares are expected to invest more resources and be more abreast with relevant information. They are also expected to use mobile phones frequently as a tool to access relevant agricultural information to improve their productivity. According to Yakubu *et al.* [14] and Falola *et al*. [16], smallholder farmers with large farm sizes are more likely to utilise ICTs in agricultural activities. Previous studies further emphasised that, commercial farmers are able to obtain higher benefits from mobile phone usage as they are able to access appropriate information on input availability and disease control with immediate technical or professional assistance compared to smallholders [28-30].

The average age of smallholder farmers and AEAs ranged from 40 to 59 (Table 2). Earlier studies [31-33] indicate that, younger farmers easily adopt agricultural innovations than aged farmers while older AEAs find it difficult to use ICT as some of them cannot use smart phones and are sometimes unable to learn new technologies. The policy implication is that, more youthful AEAs need to be recruited. Again, the age of the educated AEAs and farmers were within the youthful bracket corroborating report by Ghana Statistical Service [8-9], that roughly two-thirds (63.6 %) of the population aged 15 and above in the Eastern region are literate. This may have impacted rate of mobile phone ownership and usage for accessing and disseminating agricultural information in the districts. Majority of smallholder farmers expend between GH¢ 1 - 10 (0.26-2.60 USD equivalent at 1 USD to 3.84 GH¢ rate) on mobile phone usage per week whilst that of the AEAs ranged between 10.00-20.00 GH¢ (2.60-5.21 USD equivalent at 1 USD to 3.84 GH¢ rate) per week. Mobile telecommunications network (MTN) and Vodafone were the most patronised service providers by both smallholder farmers and AEAs (Table 2). Again, smallholder farmers with higher education use mobile phones more frequently than uneducated farmers

(Table 2). This supports findings of DiMaggio & Cohen [38] who reported that, education positively and significantly correlates with mobile phone usage.

Information type and usage frequency of mobile phone among AEAS and smallholder farmers

Majority of AEAs use mobile phones to schedule meetings (97.8 %) with smallholder farmers, send and receive text messages (89 %) to and from smallholder farmers (54.9 %) (Table 3). Conversely, majority of smallholder farmers indicated that, they receive extension advice via SMS, weather, market information (72.1 %) and sales (62.2 %) on their phones. Compared to the number of AEAs who send and receive text messages, few smallholder farmers (6.3 %) and AEAs (40.7 %) however surf the internet on their mobile phones for information on agriculture (Table 3). Twenty-six (26; 8.3 %) of the smallholder farmers transacted businesses using mobile money services provided by '*TIGO cash* and *MTN MoMo'*. One-fifth of AEAs (19.8 %) used mobile phones to report their daily activities to their supervisors. About half (47.8 %) of the smallholder farmers listen to agricultural programmes (such as agronomic practices) on radio from their mobile phones. This is consistent with Alexander *et al*. [18] who established that, agriculturalists and smallholder farmers use mobile phones to access weather forecast, market information and surf the internet. Also, Rogers [19], Syngenta Foundation [15], Ansari and Pandey [34], stated that, farmers use mobile phones for accessing market information and expert advice for agricultural emergency assistance. Both AEAs and farmers scarcely do video call/conference or multimedia messaging on social media. This compares well with report by Kwakwa [25] in Akuapim North of the Eastern region of Ghana, suggesting that farmers use voice calls more than SMS and/or video calls. Crandall [7] also reported that, voice calls using mobile phones was popular than multimedia messaging among Kenyan farmers. Ausher *et al*. [35]; Gakuru and Winters [12] argued that, SMS transmits inadequate information and requires a basic literacy level for mobile phone users; hence, the higher preference for voice calls. This concurs with the component of adoption theory of compatibility and complexity where an innovation fits within the socio-cultural framework and the perceived difficulty of use [19]. Thus, the frequent use of voice calls is indicative of early stages of the diffusion process, where the primary needs of mobile phone users may only be for voice calling. Rogers [19] also argued that, the primary justification for adoption is the perceived relative advantage that the innovation is better than an existing one. The finding supports Aker *et al.* [31], Overa [36], Jensen [37] and Mittal and Mehar [38] whose findings revealed that mobile phone use improves communications between farmers and AEAs and reduce cost of transport. However, Roger [19] noted that, a major factor that influences adoption is the five stage consequence of use: *knowledge, persuasions, decision, implementation and confirmation*. In the context of this study, *confirmation* is termed as the benefits. "*Confirmation*" is defined as where the adopter seeks information about the innovation and either continues or discontinues the use of the innovation. Based on our findings, there is no doubt that, mobile phone has the potential to enhance extension delivery and access in the Eastern region of Ghana. Agricultural extension agents and smallholder farmers in the study areas preponderantly used mobile phones to deliver and access market information, learn about good agronomic practices, and new crop varieties (n = 33; 36.3 %), access weather forecasts, fertiliser application and post-harvest practices (n = 29; 31.9 %),

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respectively; less than 15 % of farmers used mobile phone on all the above (Table S1). Frequency of usage was measured as the number of times smallholder farmers or AEAs used mobile phones to access or send agricultural information. Agricultural extension agents (Mean = 4.42, SD = 0.79) and smallholder farmers (Mean = 4.80, SD = 0.45) used phones for voice calls four times weekly to deliver and access agricultural information (Table S2). Additionally, the AEAs use mobile phones twice a week to access internet (Mean = 2.32, SD = 1.51); email (Mean = 2.26, SD = 1.52) and to receive or send information on WhatsApp (Mean = 2.57, SD = 1.81) (Table S2).

The amount of money expended per week on mobile phones has a positive and significant correlation with frequent use of mobile phone. The result is in consonance with reports by Vishwanath and Goldhaber [28] and Poulton *et al*. [39]. The finding that farmers who belong to farmer-based organisation (FBO) frequently use mobile phones than their non-associated counterparts is consistent with reports by Falola *et al*. [16] that, FBO membership positively and significantly correlates with mobile phones usage among smallholders. Farmers in FBOs often engage in peer learning and seek assistance from co-farmers to access information. Analysis of age differential indicates that, young farmers use mobile phones more frequently and competently compared to older ones corroborating the findings of Munya [23], Okello *et al*. [27], and Williams and Agbo [29], Porcari [40] who concluded that, young farmers are far more adept at using newer innovations (social networking and IoTs technologies) than the aged. Young AEAs with less working experience and AEAs with smaller household sizes repeatedly use mobile phones in agricultural extension delivery than older AEAs who have large family sizes, result which is consistent with findings of Yakubu *et al*. [14] in Nigeria, Dereje *et al.* [41] in Ethiopia and Muhamah *et al*. [42] in Pakistan. Younger AEAs with less career experience graduated comparatively recently when ICT subjects were incorporated in agricultural training curricula. The finding that the more educated AEAs are, the more they utilise mobile phones in extension delivery is consistent with findings of DiMaggio and Cohen [38] who established that education positively and significantly correlates with mobile phone usage.

Competency levels and perceived benefits of mobile phone usage by smallholder farmers and AEAs in agricultural extension

Twelve (12) items were constructed to measure competency levels of smallholder farmers and AEAs. Agricultural extension agents (AEAs) competencies in voice call (Mean = 4.80, SD = 0.50), text messaging (Mean = 8.94, SD = 1.39), and listening to radio (Mean = 3.76, SD = 1.62) on mobile phones were high (Table 4). Smallholder farmers' competency in voice call (Mean = 4.52, SD = 0.60) was also high. Smallholder farmers' competency in using radio on mobile phones was however moderate (Mean = 2.51, SD = 1.69). Competencies of both smallholder farmers and AEAs in using social media, video call, and other mobile apps were low (Table 4). Majority of the farmers (Mean = 1.98, SD = 0.64) had low competency level whilst AEAs (Mean = 2.95, SD = 0.69) had moderate competency in the use of mobile phones in extension service access and delivery. The independent t-test affirms a significant (p = 0.01) difference between AEAs and farmers' competency levels in the use of mobile phones for agricultural extension service delivery and access. Therefore, the null hypothesis that '*there is no substantial difference between smallholder farmers and*

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AEAs competency levels in mobile phone usage' is rejected and in support of the alternative hypothesis. Alexander *et al*. [18], however reported that limited competency in usage of communication services by both smallholders and AEAs accounts for limited access and usage of relevant information in the agriculture sector in Ghana. Smallholder farmers (Mean = 3.34, SD = 1.07) and AEAs (Mean = 3.91, SD = 0.17) indicated that, mobile phone permits timely acquisition of information on input prices, markets and good agronomic practices. However, while smallholder farmers (Mean = 3.69, SD = 0.86) and AEAs (Mean = 3.10, SD = 1.03) indicated that, mobile phone usage reduces theft risks, AEAs (Mean = 3.65, SD = 1.06) and smallholder farmers (Mean = 3.32, SD = 0.88) indicated that mobile phone usage reduces operational cost and increases savings. Both AEAs and smallholders acknowledged that mobile phone usage decreases transport costs, enhances communication with suppliers, customers and AEAs, and eases links to supply chain companies (Table S3). Previous studies have shown that mobile phone usage among smallholder farmers increases income [7], shrinks production costs [8, 9], increases productivity [10] and enhances communication with agri-food suppliers/farmers and consumers [11]. Furthermore, mobile innovation has lowered hunger and improved rural living standards [1, 12-17].

Regression and correlation analyses of socio-demographic characteristics of smallholder farmers and AEAs, and mobile phone usage frequency for agricultural extension

A multi-linear regression analysis of the effects of key socio-economic/demographic characteristics (such as education, income, network reception quality, age, type of mobile phone and amount of money expended per week) on frequency usage of mobile phones by smallholder farmers and AEAs (Table 5) was performed. The regression analysis revealed that 4.1 % of all variances in smallholder farmers' usage frequency of mobile phones were influenced by money expended per week and the quality of network reception, while the type of mobile phone, money spent weekly and age were the key predictors of usage frequency of mobile phones by AEAs, accounting for 55.0 % of the variance (Table 5). By this finding, the quality of mobile network in an area and how much farmers or AEAs spend on recharging credit determine the frequency at which farmers or AEAs use mobile phones to exchange agricultural information. This is consistent with Vishwanath and Goldhaber [28] and Poulton *et al.* [39] who reported that low incomes hamper smallholder farmers' level of technology adoption.

Twelve variables were found to be associated with the frequency of mobile phone usage by smallholders; four were significant ($p \leq 0.05$) (Table 6) while 10 variables were associated with AEAs' mobile phone usage frequency except sex ($r = 0.03$), experience in mobile phone usage ($r = -0,10$) and marital status ($r = 0.1$). Therefore, the null hypothesis that, *'there is no substantial relationship between socio-demographic characteristics of AEAs and smallholder farmers and frequency of usage of mobile phone'* was in support of the alternative hypothesis.

There was positive but significant association between education ($r = 0.12$, $r = 0.21$; $p = 0.00$) and frequency of usage of mobile phones for both smallholder farmers and AEAs (Table 6). Amount of money expended per week ($r = 0.43$, $r = 0.16$; $p = 0.00$) and type of mobile phone use has a negative correlation coefficient ($r = -0.71$; $p = 0.05$) and is

significantly associated with frequency of usage of mobile phones for both smallholder farmers and AEAs (Table 6). A recent study by Dereje *et al.* [41] reported that, income level has a positive and significant correlation with the use of ICTs in agricultural extension. This implies that, farmers with higher income levels can use mobile phones regularly to access information in their production activities.

Again, membership of smallholder farmers with farmer-based organisations (FBOs) has a positive correlation coefficient and significant association ($r = 0.18$; $p = 0.00$) with usage frequency of mobile phones in accessing extension services (Table 6). The quality of mobile network in the study areas was determined and how much farmers or AEAs spent on recharging credit and predicted the frequency at which farmers or AEAs used mobile phones in agricultural extension. The quality of network reception had a positive correlation coefficient and significant association ($r = 0.12$, $r = 0.7$; $p = 0.00$) with frequent use of mobile phones in extension service access by smallholder farmers, but not significant for AEAs (Table 6). Age ($r = -0.54$), household size ($r = -0.31$), working experience ($r = -0.48$), and type of mobile phones use by AEAs inversely correlated with mobile phone usage frequency (Table 6). The result is consistent with Vishwanath and Goldhaber [28] and Poulton *et al.* [39] who reported that, poor mobile connectivity and low incomes hamper smallholder farmers' technology adoption.

CONCLUSION

The study assessed user competency and frequency of mobile phone usage in access to agricultural extension services and delivery in the Eastern region of Ghana. There were varying competency levels in the use of mobile phones among smallholder farmers and AEAs in the study areas. Competency level of users partly affects the frequency of mobile phone use for agricultural extension. A special tax incentive for service providers to channel some of their profits to subsidise cost of extension service by the Ministries of Food and Agriculture, and Communication is recommended. Farmer-based organisations should also be resourced to support training of farmers to use mobile phones to improve access to agricultural information. Incorporating voice-based agricultural information services (IVRs) into the current SMS-based agricultural extension services could further enhance extension service provision to smallholder farmers in Ghana and across Africa. Again, extension agencies may liaise with mobile service providers to train farmers and AEAs in video calling/conferencing, multimedia service, and use of social media to boost their competencies in the use of these applications for enhancing agricultural extension services.

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Table 1: Sample size of registered farmers and AEAs in the selected Districts

District	[a] Mobile phone ownership	Registered farmers	Sample size	
			Smallholder farmers	AEAs
Fanteakwa	25,516	509	70	26
Kwawu South	22,537	320	44	14
Yilo Krobo	26, 729	343	47	27
Upper Manya	11,792	453	63	14
Akuapim South	46, 121	768	105	14
Total	**132, 695**	**2, 393**	**330**	**95**

Source: *[a]Ghana Statistical Service (2013); Field Survey, 2017*

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Table 2: Socio-demographic characteristics of AEAs and smallholder farmers

Characteristics	AEAs		Smallholder farmers	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Sex*				
Male	81	89.0	242	76.8
Female	10	11.0	73	23.2
Age (years)				
15-30	24	26.4	69	21.9
31-45	24	26.4	92	29.2
46-60	43	47.3	96	30.5
61 and above	-	-	58	18.4
Mean	46.33		49.46	
Standard deviation	8.89		11.11	
Educational level				
J.H.S/middle school.	-	-	175	55.8
S.H.S/post-SHS	67	73.7	85	27.1
University/post-university	24	26.4	4	1.3
No formal education	-	-	50	15.9
Marital status				
Married	83	91.2	247	78.4
Single	8	8.8	46	20.6
Household size				
1-5	68	69.2	166	52.0
6-10	28	30.8	128	40.6
11-and above	-	-	22	7.0
Mean	4.73		5.89	
Standard deviation	2.20		3.13	
Working experience (years)				
1-10	23	25.3	84	26.6
11-20	25	27.5	120	38.4
21- and above	43	47.3	111	35.1
Mean	18.45		18.45	
Standard deviation	9.360		10.31	
Farm size (hectare)				
1-10	-	-	266	86.9
11-20	-	-	29	9.5
21-30	-	-	11	3.7
Mean	-		18.45	
Standard deviation	-		10.31	
Weekly phone usage expenditure (GH₵)				
1-10	86	94.6	285	90.8
11-20	5	5.6	22	7.0
21-30	0	0	7	2.2
Mean	8.00		6.35	
Standard deviation	3.47		5.39	
Major agricultural activity*				
Crop production	-	-	311	98.7
Animal production	-	-	112	35.6
Agro-processing and marketing	-	-	21	6.6
Fish farming	-	-	11	3.5
Source of agri-information*				
Co-farmers/colleagues	71	74.5	265	84.1
AEAs/MoFA	85	93.4	261	82.9

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FBO membership*			229	72.7
Radio/TV	60	65.9	97	30.8
Workshop/conference	89	97.9	114	36.2
Farmers' forum/farmer field school	60	65.9	95	30.2
Researchers/NGOs	60	65.9	94	29.8
Type of phones*				
Non-smart phone	46	50.6	33	10.7
Smart phone	66	72.5	287	91.1
Mobile phone usage experience (years)				
1-10	56	61.6	300	95.2
11-20 and above	35	38.4	15	4.8
Mean	10.04		8.08	
Standard deviation	2.04		1.85	
Cellular network subscription*				
MTN	84	92.3	236	74.9
Vodafone	32	35.2	55	17.5
Airtel	18	19.8	30	9.5
Tigo	8	8.8	50	15.9
Expresso	4	4.4	6	1.9
Glo	2	2.2	1	0.3
Network subscription considerations*				
Wider coverage	89	97.8	206	65.4
Good reception	70	76.8	279	88.6
Promotions (*voice calls, sms, mms, video calling*)	47	51.7	127	40.2
Promotes agri-information	8	8.8	3	1.0

Source: *Field Survey, 2017; * Multiple responses. Vodafone, Airtel, Tigo, Expresso and Glo were the major telecom service providers in Ghana at the time of the study*

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Table 3: Major uses of mobile phone in extension service access and delivery

Phone use	AEAs (N = 91)		Smallholder farmers (N = 315)	
	Freq.	Percent	Freq.	Percent
Scheduling meetings with smallholder farmers*	89	97.8	-	-
Sending/receiving texts	81	89.0	-	-
Input delivery/procurement	-	-	120	38.1
Gathering market information*	50	54.9	227	72.1
Accessing internet for agri-information	37	40.7	20	6.3
Transferring money (mobile money)	35	38.5	26	8.3
Reporting extension work	18	19.8	-	-
Listening to agricultural programme on radio	1	1.1	141	47.8

Source: *Field survey data (2015-2017). * Multiple responses*

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Table 4: Competency level of smallholder farmers and AEAs in mobile phone usage

User competency	AEAs (N = 91)		Smallholder farmers (N = 315)	
	Mean	SD	Mean	SD
Voice call	4.80	0.50	4.52	0.60
Text messaging	4.94	1.39	4.59	2.57
Listening to radio on phone	3.76	1.62	2.51	1.69
Surfing the internet	4.09	1.36	2.58	1.82
Social media chat (WhatsApp, Facebook & Twitter)	4.94	1.80	3.61	2.11
Using multimedia service	2.57	1.82	2.13	0.71
Video calling on phone	1.23	0.70	1.05	0.24

Mean computed from a Likert scale of 1 = very low, 2 = low, 3 = moderate, 4 = high, 5 = very high
The mean and standard deviations were computed from frequency of responses against sum of the scores (Likert scale)

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Table 5: Regression analysis of the effects of socio-economic/demographic characteristics of smallholder farmers and AEAs, on frequency of usage of mobile phone for agricultural extension

Predictors	DF	β	Std error (b*)	F	P-value
Money expended per week**	1	0.18	0.03	8.16	0.01
Quality of network reception**	2	0.15	0.05	7.06	0.01
Type of mobile phone***	1	0.52	0.59	86.34	0.00
Amount of money expended per week***	2	0.34	0.53	7.20	0.00
Age*	3	0.20	0.66	6.10	0.015

Source: *Field survey (2017). N = 315; ** p = 0.01 level (2-tailed); * p = 0.0level (2-tailed). Dependent variable (X1): = Predictor variable. The regression model for frequency of usage of mobile phone by smallholder farmers was: Y = 1.812 + 0.178 X 9 + 0.1511 X 11, where the dependent variable (Y) refers to frequency of usage of mobile phone, amount expended per week (X9) and quality of network reception (X11); and that for AEAs was: Y = 0.156 + X 11 0.495 + X8 0. 534 + X2 0.565 where X11, X8 and X2 refer to type of mobile phone; amount of money expended per week and age, respectively*

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Table 6: Correlation between mobile phones usage frequency and socio-demographic characteristics of smallholder farmers and AEAs

	Smallholder farmers		AEAs	
Independent variables	Correlation co-efficient	P-value	Correlation co-efficient	P-value
Sex	-0.05	0.43*	0.03	0.76
Age (years)	-0.05	0.43	-0.54	0.00**
Education level	0.12	0.00**	0.26	0.00**
Marital status	0.05	0.38	-0.04	0. 76
Household size	-0.10	0.07*	-0.31	0.00**
Years of farming/working experience	0.04	0.48	-0.48	0.00**
Farm size	0.07	0.19	-	-
Mobile phone usage experience (years)	-0.03	0.60	-0.10	0.36
Amount expended per week on recharge	0.16	0.00**	0.43	0.00**
FBOs membership	0.18	0.00**	-	-
Quality of network	0.12	0.00**	0.07	0.49
Mobile phone type	-0.00	1.04	-0.71	0.00**

Source: *Field survey data (2017). **p = 0.01 level (2-tailed); *p = 0.05 level (2-tailed) computed using standard Pearson correlations*

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Table S1: Type of agricultural information AEAs and smallholder farmers access with mobile phones

	AEAs		Smallholder farmers	
Type of information	*Freq.	%	*Freq.	%
Market information	33	36.3	41	13.0
Good agronomic practices	33	36.3	41	13.0
New crops variety	32	35.2	41	13.0
Diseases management (crops)	31	34.1	42	13.3
Weather information	29	31.9	46	14.6
Recommended fertilisers	29	31.9	41	13.0
Post-harvest handling	29	31.9	40	12.7
Workshops/training	26	28.6	41	13.0
Planting materials	25	27.5	37	11.7
Poultry management	25	27.5	10	3.2
Pest management	24	26.4	38	12.1
Livestock management	23	25.3	22	7.0
Disease management (animals)	21	23.1	34	10.8
Weeding and thinning	18	19.8	39	12.5
Animal health management	16	17.6	29	9.2
Good slaughtering practices	6	6.6	12	3.8
Fishery	2	2.2	7	2.2

Source: *Field survey data (2017). * Multiple responses*

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Table S2: Usage frequency of mobile phones by smallholder farmers and AEAs

Service	AEAs (N = 91)		Smallholder farmers (N = 315)	
	Mean	SD	Mean	SD
Voice calling (voice calls)	4.80	0.45	4.42	0.79
Text messaging	4.96	2.07	3.79	1.90
Listening to radio on phone	3.09	1.75	2.15	1.63
Social media chats (WhatsApp, Facebook and Twitter)	4.75	3.45	3.42	1.69
Surfing the internet (email and browsing)	4.58	3.03	2.43	1.42
Multimedia service	2.28	1.20	2.05	0.30

Means were estimated from a Scale of: 0 = never, 1 = once a week, 2 = twice a week, 3 = thrice a week, 4 = four times and above

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Table S3: **Smallholder farmers and AEAs perceived benefits of using mobile phone in extension**

Benefits	AEAs (N = 91)		Smallholder farmers (N = 315)	
	Mean	SD	Mean	SD
Reduces transportation/travelling cost	4.22	0.84	4.11	0.67
Timely alert of price, markets and information on good agricultural practices	3.91	0.85	3.34	1.07
Improves communications with suppliers/customers and AEAs	3.88	0.82	3.78	0.87
Improves product/service delivery	3.86	0.81	3.73	0.97
Eases connecting with co-farmers, off-takers, traders and buyers	3.85	0.89	3.66	1.06
Increases farmers profit margin	3.66	0.92	3.60	0.86
Lowers operational cost/increases savings	3.65	1.06	3.32	0.88
Reduces risks of theft	3.10	1.03	3.69	0.86

Source: *Field survey data (2017). scale: 1 = strongly disagree, 2 = disagree, 3 = moderately, agree, 4 = agree, 5 = strongly agree*

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