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Mobile agricultural extension delivery and climate-smart agricultural practices in a time of a pandemic: Evidence from southern Ghana

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ABSTRACT

During the Covid-19 era, Ghana's cocoa sector relied heavily on mobile phone agriculture for extension delivery services, aiming to enhance climate-smart agricultural activities and overcome physical limitations. However, there is limited literature on the role of mobile phones in extension delivery during the pandemic. The study investigated the effectiveness of mobile phone agriculture in extension delivery and its relationship with climate-smart agricultural practices in Ghana's cocoa sector during the pandemic. The study selected 152 community extension agents in the Ashanti Region. The cross-sectional data was estimated using frequencies, percentages, means, standard deviations Pearson, Point Biserial, Spearman rho, and ordinary least squares regression. The result indicates a positive correlation between mobile phone agriculture extension delivery and climate-smart agricultural practices. Additionally, there was a significant relationship between climate-smart practices and factors such as knowledge, skills, frequency, and intensity of phone use. However, years of experience and age showed a negative relationship. The findings showed that funding, knowledge of use, and years of experience as influential factors in climate-smart agricultural activities facilitated by mobile phone extensions. To reach underserved cocoa communities, the Ghana Cocoa Board must enhance the capacity of community extension agents. Countries considering an intensive adoption of mobile phone agriculture for innovative extension services in climate-smart agriculture should consider factors like knowledge, skills, duration, frequency, and financial investments in acquiring, converting, applying, protecting, and distributing climate-smart agricultural information. The study contributes to mitigating the negative impact of climate change through the application of climate-smart information in agriculture.

1. Introduction

Ghana's agricultural development has been mostly driven by profitable crops, especially cocoa (Eberhard et al., 2022). Ghana is the second largest producer of cocoa, placing second to Cote d'Ivoire. Despite the remarkable progress and achievement, the reduction in yields has been of concern. In the 2014/15 cocoa season, Ghana was ranked second in terms of contribution to the world's cocoa production (17.6%) yet the annual cocoa production in Ghana decreased from 897 thousand tonnes in 2013/14 to 740 thousand tonnes in 2014/15 cocoa season representing a decrease of 17.5% (International Cocoa Organization, 2015). The related literature (Hatly et al., 2012; Cumhur and Malcolm, 2008; Manatsa et al., 2017; Mittal and Mehar, 2012), ascribes the decrease in cocoa yield to variable weather conditions, soil degradation, insects, and diseases. Although climatic variations have a significant impact on agriculture (Cumhur and Malcolm, 2008), cocoa is a crop that is known to be very vulnerable to climate change (Manatsa et al., 2017). The influence of climate change on agriculture has been well explored in the global south (Farook and Kannan, 2015; Anum et al., 2022), and these changes are recognized to exacerbate current obstacles in enhancing crop yield and farm family welfare (Mullins et al., 2018). Smallholder farmers in Sub-Saharan Africa are vulnerable to climate change

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(Manatsa et al., 2017). This situation, therefore, necessitates the adoption of methodologies that enhance smallholder livelihoods, reduce their susceptibility to climate change and boost their coping strategies (Lipper and Zilberman, 2018). Climate Smart Agriculture (CSA) as a climate change adaptation strategy aids farmers in reducing susceptibility, increasing climate change adaptation capacity, and better coping with ex-post risk (Lipper et al., 2014) by ensuring food security and contributing to other developmental objectives (Verhagen et al., 2014; Anang et al., 2020).

Farmers' susceptibility to the risks and uncertainties associated with climate change is sometimes aggravated by a lack of knowledge about weather and proper farm management (Mittal and Mehar, 2012). Akpotosu et al., (2017), argued that the timely availability of relevant information is critical for the execution of administrative responsibilities such as planning, organizing, directing, and controlling agricultural enterprises. Primarily, agricultural extension agencies must pass on knowledge to farmers to facilitate successful learning and social change. However, the overwhelming extension agent-to-farmer ratio of '1:1500' in Ghana makes it difficult for extension services to offer essential technology and information to farmers promptly (Anang et al., 2020).

Furthermore, effective extension in Ghana faces challenges such as a lack of a single line of command, attenuation of efforts by assigning too many jobs to extension workers, excessively large areas of operation without providing any logistic support, lack of regular training for extension workers to update their knowledge, lack of research findings appropriate to the condition of farmers' fields and duplication of services by various agencies (Asiedu-Darko, 2013; Akpotosu et al., 2017). Unfortunately, during the Covid-19 era, these challenges were exacerbated, and community extension agents (CEAs) in Ghana's cocoa sector were forced to intensify their use of mobile phone agriculture (MPA) extension delivery services in ensuring adherence to the Covid-19 protocols which included social and physical distancing. Indeed, Ankrah et al. (2021) and Agyei-Holmes et al. (2021) showed that Covid-19 presented challenges to Ghana's agricultural food systems. How agricultural extension services were delivered in the context of Covid-19 via mobile phones is a focus for thinking and action.

Several studies (Ali and Kumar, 2010; De Silva et al., 2010; Fafchamps and Minten, 2012; Mittal, 2016; Mittal et al., 2010; Mittal and Mehar, 2013; Muto and Yamano, 2009) in Southern Asia and Africa have demonstrated the transformative potential of modern information and communication technologies (ICTs) in agriculture, as well as their appropriateness to addressing existing information asymmetry. The use of mobile-enabled information distribution tools has the potential to improve the adoption of modern technologies, inputs, and best practices (Mittal and Mehar, 2016). As a result, mobile has become a popular tool among farmers for communicating and obtaining agricultural-related information (Akmal et al., 2019). Hence, with the new agricultural development paradigm of using mobile phones, traditional ways of delivering valuable information to farmers "face to face" are being challenged, and traditional societies are being integrated into knowledge societies all over the world, causing people in rural settings to think and act differently (Mittal, 2016; Noor et al., 2018).

The growing usage of mobile networks and phones, as well as the recent launch of several mobile-enabled information services in rural areas, allows for making relevant information more universally accessible (Fischer et al., 2009; Mittal and Mehar, 2013). However, technology thrives on trust and security of the service providers, thus, this aspect must be viewed as important or vital regardless of how well it is created (Gathecha et al., 2012). Therefore, the Ghanaian government through the Ghana Cocoa Board[1] (COCOBOD) in collaboration with private companies introduced farmer-friendly mobile apps such as Cocoa-link (initiated by Hersheys), Farming Solution (Solidaridad), and MergeData (Farmerline) to send CSA information to cocoa farmers to improve MPA extension delivery, particularly in the cocoa sector of Ghana in 2011.

Interestingly, prior studies examining the application of mobile phone technologies for agricultural extension delivery have been conducted in the context of farmers' ability to adopt modern technologies, inputs, and best practices using mobile phones. The Ghanaian setting presents an interesting context to examine the link between mobile agricultural extension delivery and climate-smart agricultural practices in a time of a pandemic. In another disposition, Jones et al. (2022) examined CEAs perceived effect of knowledge management capacity on the performance of the Cocoa Health and Extension Division (CHED) in Ghana, by diving deeper into processes and procedures of knowledge handling, yet the extant literature remains scarce on the level of MPA used for the adequate acquisition, conversion, application, protection, and distribution of CSA information in Ghana's cocoa industry. Again, the level of knowledge, skills, duration, frequency, and financial intensity invested in the use of MPA over the traditional face-to-face extension delivery method in the Ghanaian context is not very profound in the literature. Furthermore, the nature of CSA information transferred to farmers via mobile phones in terms of productivity and income, building resilience to climate change, and reducing greenhouse gas emissions in Ghana's cocoa sector is less defined. This study contributes to the literature in multiple folds by providing empirical data about the components for the dissemination activities using mobile phones under the CSA project of the COCOBOD. Specifically, this study sought to find out how the Cocoa Extension Agents perceive the use of mobile phones in dissemination of the CSA information particularly in a time of pandemic where the traditional contact extension delivery method was affected by the physical and social distancing protocols that prohibited physical and social contact meetings. The main aim of the study is to investigate the linkages between MPA and CSA in Ghana's cocoa sector as experienced by CEAs during the covid-19. Specifically, the study addresses inquiries regarding the magnitude of MPA and CSA implementation, the correlation between MPA and CSA, and the ability of CSA practices on farms to be predicted based on the MPA skills demonstrated by CEAs in the cocoa industry of Ghana. The study, therefore, answers the following questions: i) How do CEAs perceive the level of MPA in Ghana's cocoa sector? ii) How does funding impact the use of mobile phones? iii) How do CEAs perceive the level of CSA extension delivery during the Covid-19 pandemic? iv) What is the correlation between MPA extension delivery and CSA? and v) Which components of the MPA are predictive of the operationalization of CSA?

2. Methodology

2.1. Study area

The study was performed in the Ashanti Region (Fig. 1), one of the 16 regions in Ghana that has Kumasi as its regional capital. The Ashanti Region is found in the southern part of Ghana and is the third biggest of 16 administrative regions, invading a total land surface of 24,389 km^2 (9417 mi^2) of the total land area of Ghana. In terms of population, the Ashanti Region is a greatly populated region with a population of 4,780,380 according to the 2011 census, accounting for 19.4% of Ghana's total population. The Ashanti Region is known for its mining (gold) and cocoa production. The Ashanti Region is centrally found in the middle belt of Ghana. It lies between longitudes 0.15W and 2.25W, and latitudes 5.50N and 7.46N. The region shares barriers with six of the sixteen political regions, Bono, Bono East and Ahafo Regions in the north, the Eastern region in the east, the Central region in the south and the Western region in the Southwest. The region is divided into 27 districts, each headed by a District Chief Executive. The region experiences double maxima rainfall in a year, with results in May/June and October. Mean annual rainfall is between 1100 mm and 1800 mm (https://Igs.gov.gh/index.php/ashanti).

It has about 79 settlements with about 61% of them being rural, the

[1] The mother organization that oversees all cocoa activities in Ghana.

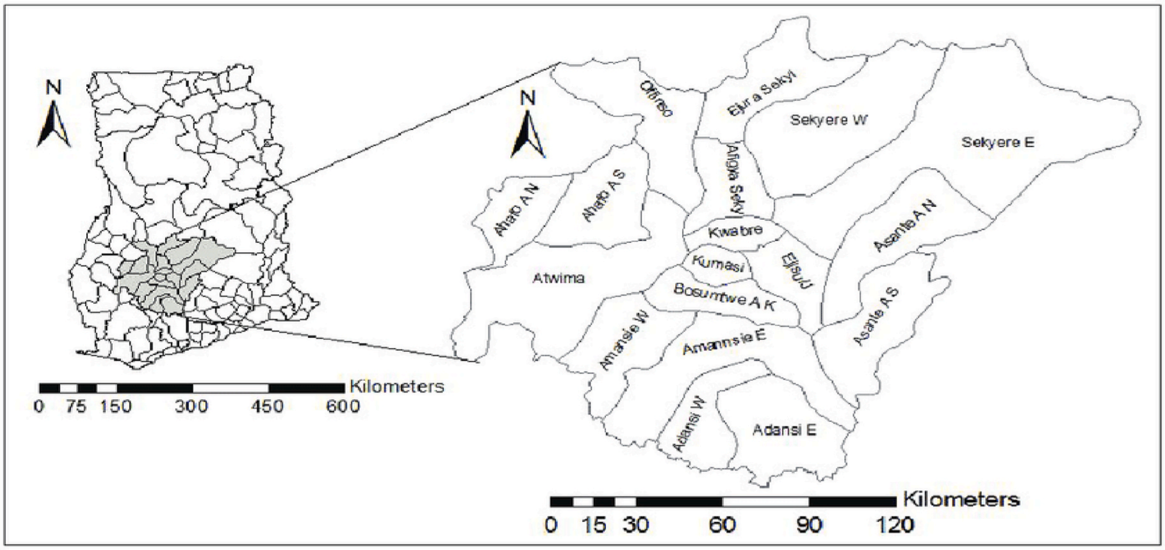

Fig. 1. Map of the ashanti region.

rural areas are mostly found in the northern part of the region where village communities with an average of less than 200 people live in dispersed patterns. The major rainy season start in March and ends in August whiles the minor rainy season is between September and November. The remaining months span the dry season. The region lies within the west semi-equatorial forest zones. Due to human activities such as charcoal production, lumbering, bushfires, and illegal mining, the forest vegetation particularly in the northeast parts of the region, is gradually being reduced to savanna. Agricultural activities in the Region include the cultivation of crops or tree planting, rearing of livestock, and breeding of fish for sale or family consumption. The mean annual temperature ranges between 25.5°c in the southern districts and 32°c in the northern parts of the region. Humidity is great averaging about 85% in the southern districts and 65% in the northern part of the region. Agriculture is the dominant sector in the region's economic activities, and it is enriched with abundant arable lands which aid the production of cash crops such as cocoa, coffee, oil palm, citrus cashew, mango, and food crops like cassava, plantain, rice, yam, cocoyam, maize, and vegetables (https://lgs.gov.gh/index.php/ashanti).

2.2. Sample and sampling procedure

In the Ashanti Region, Ghana's cocoa-producing spaces have been divided into four (4) primary cocoa operating zones, namely Western, Southern, Northern, and Eastern. All the CEAs in the cocoa district offices operating zones in the Ashanti area were utilized for this research. The whole population of CEAs in the four (4) operating zones was included in the sample frame obtained from CEA offices, which numbered up to 212. To obtain individual CEAs to answer the surveys, a simple random sample procedure was used at the different operating zones. According to the Krejcie and Morgan (1970) sampling table, 152 CEAs is a representative sample for size for a population of 212 CEAs in the four (4) operating zones in the Ashanti area (Krejcie and Morgan (1970); Akpotosu et al., 2017).

2.3. Data collection procedure

The questionnaires were administered during training sessions and monthly meetings in each of the CEAs' respective districts. The District and Municipal coordinators of CHED were contacted for monthly meeting/training schedules dates which made it possible for the researchers to meet all CEAs. The data was gathered between June and September 2021.

2.4. Data analysis

Data collected from the field was organized, edited, coded, and entered for analysis using the Software Package for IBM SPSS version 21.0. All hypotheses for significant differences and relationships were tested at the 0.05 alpha levels. Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to examine CEAs' perceived level of efficacy in MPA in addition to the CEAs' perceived level of CSA practices.

Correlational coefficients (Pearson, Point Biserial, and Spearman rho) were run to examine the relationship between the level of efficacy of knowledge management capacity and the level of CSA practices. To assess the best predictors of CSA extension delivery from the main components of MPA, ordinary least squares regression (OLS) analysis involving the stepwise entry method was employed. The regression equation used was

$$Y = a + \beta_{10} X_{10} + \beta_9 X_9 - \beta_6 X_6 - \beta_3 X_{3+} \varepsilon \quad (1)$$

$$Y = a \ if \ \beta_2 = \beta_8 = \beta_{12} = 0 \quad (2)$$

Where, Dependent Variable (Y) = CSA a = constant ε = Error term, $_{Xn}$ = MPA.

3. Results

3.1. Demographic characteristics of CEAs

In terms of gender distribution, most responders (55.3%) were males with fewer female CEAs (44.7%). The study further shows that most of the respondents (98.7%) were between the ages of 21 and 40 years old. Again, more than half of the respondents (80.0%) had bachelor's degrees or higher. Most CEAs (92.6%) had working experience ranging from 1 to 20 years in agreement (see Table 1).

3.2. CEAs perceived level of MPA in Ghana's cocoa sector

In Table 2, the overall ratings of procedures of acquisition (x = 4.36, SD = 0.694), conversion (x = 4.38, SD = 0.692), application (x = 4.24, SD = 0.719), protection (x = 4.34, SD = 0.692), and distribution (x = 4.24, SD = 0.654) of CSA information via MPA were all high with little variant responses. Again, the overall assessment of CEAs knowledge (x

Table 1
Analytical framework.

Domain	Data component	Instrument: measurement	Data analysis
Perceived level of the MPA	Level of knowledge, skills, duration, frequency, and financial investments in the acquisition, conversion, application, protection, and distribution of CSA information	Structured questionnaire: Scale	Descriptive statistics: Percentages, Frequencies, means, standard deviation
Perceived level of CSA	productivity and income, building resilience to climate change, and reducing greenhouse gas emissions	Structured questionnaire: Scale	Descriptive statistics: Percentages, Frequencies, means, standard deviation
Relationship between MPA and CSA	Components of MPA and CSA	Structured questionnaire: Scale	Inferential Statistics: Spearman rho, Point Biserial, Pearson correlation
Predictability of MPA on CSA	Components of MPA and CSA	Structured questionnaire: Scale	Inferential Statistics: OLS regression used in a stepwise entry

= 4.42, SD = 0.637), skills (x = 4.08, SD = 0.724), frequency (x = 4.36, SD = 0.703), and magnitude (x = 4.20, SD = 0.707) in CSA mobile-App usage were high, with little variance in response.

3.3. CEAs perceived funding in the use of mobile phone

Table 3 shows the total perceived contribution of funding for the use of mobile phones in the dissemination of CSA by the CEAs. The result indicates that the total contribution of funding was rated very high (x = 4.51, SD = 0.681). Individually, Cocoa boards' ability to get support in the form of funding from other stakeholders for CSA activities (x = 4.51, SD = 0.681) contributed at a high level to the total funding of mobile phone use for CSA extension delivery.

3.4. CEAs perceived level of climate-smart agricultural extension delivery during the Covid-19 pandemic

Table 4 shows that the overall ratings of CSA in terms of increased productivity and income (x = 4.5, SD = 0.682), building climate change resilience (x = 4.5, SD = 0.318), and reduction in greenhouse gas emissions (x = 4.1, SD = 0.681) were very high with little variation in CEAs responses. At the increased productivity and income level, increased food, and crop security (x = 4.51, SD = 0.680) was a protuberant resultant effect of the use of mobile phones for the dissemination of CSA. However, at the building climate change resilience level, collaboration with other climate change advocacy organizations was a prominent resultant effect of the use of mobile phones for the dissemination of CSA. At the reduction in greenhouse gas emissions level, reduced emission of greenhouse gases in farmer cocoa fields (x = 4.52, SD = 0.670) was a bulbous resultant effect of the use of mobile phones for the dissemination of CSA.

3.5. Relationships between MPA extension delivery and climate-smart agricultural practices

The Pearson product-moment correlation matrix was used to test for the relationship that exists between MPA extension delivery and CSA. The Pearson product-moment correlation matrix for the research variables is presented in Table 5. The correlation coefficient (r) was interpreted according to the guidelines recommended by Davis (1971); Bosompem et al. (2013) which is scaled as 1.0 = Perfect, 0.70–0.9 = Very High, 0.50–0.69 = Substantial, 0.30–0.49 = Moderate, 0.10–0.29 = Low and 0.01–0.09 = Negligible to depict the strength of relations between the independent and dependent variables. There was a positive and very high significant relationship between CSA information dissemination and funding (r = 0.807) for phone use at 0.01 alpha level. However, there was a negative and moderate significant relationship between CSA activities and years of experience (r = 0.807) at 0.01 alpha level and a negative and low significant relationship between CSA and age (r = −0.193) at 0.05 alpha level (see Table 6).

3.6. Collinearity diagnostic test

The Variance Inflation Factor (VIF) ranged from 1.0 to 2.6 and the tolerance ranged between 0.3 and 0.9 and the Durbin Watson was 1.9.

3.7. Ordinary least squares regression of MPA extension delivery on climate-smart agricultural practices

A ten (10) factor linear regression model comprising of Sex (X1), Age (X2), Years of experience (X3), Level of education (X4), Extension Zone (X5), Knowledge (X6), Skills (X7), Frequency (X8), Magnitude (X9), Funds (X10) was projected to clarify the variation of MPA extension delivery components on CSA. The OLS regression was used in a stepwise

Table 3
Total contribution of funding of mobile phone use.

Funds were provided for mobile phone use to aid me to	Mean	Std. Dev.
Access the internet for CSA activities	4.50	.681
Purchase airtime for CSA activities	4.51	.682
Maintain my smartphone for CSA activities	4.50	.683
Get support from other stakeholders for CSA activities	4.52	.681
Get new technology for CSA activities	4.51	.680
Total funding for use of mobile phone	4.51	.681

Source: Field Data, 2022. n = 152. Scale: 1.00–1.44 = very low (VL), 1.45–2.44 = low (L) 2.45–3.44 = moderate (M), 3.45–4.44 = high (H), 4.45–5.00 = very high (VH).

Table 2
CEAs' perceived level of MPA in Ghana's cocoa sector.

Competencies Domain	Acquisition		Conversion		Application		Protection		Distribution		Total Mean	Total Std. Dev.
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev.	Mean	Std. Dev.		
Knowledge of mobile phone use	4.5	0.68	4.5	0.68	4.5	0.68	4.5	0.68	4.1	0.47	4.4	0.64
Skill of mobile phone use	4.5	0.68	3.9	0.74	3.9	0.76	4.5	0.68	3.6	0.76	4.1	0.72
Frequency of mobile phone use	4.5	0.68	4.5	0.68	3.8	0.80	4.5	0.68	4.5	0.68	4.4	0.70
Magnitude of mobile phone use	3.8	0.75	4.5	0.68	4.5	0.68	3.7	0.74	4.5	0.68	4.2	0.71
Overall rating	4.36	0.69	4.4	0.69	4.24	0.72	4.34	0.69	4.2	0.65	4.3	0.69

Source: Field Data, 2022. n = 152. Scale: 1.00–1.44 = very low (VL), 1.45–2.44 = low (L) 2.45–3.44 = moderate (M), 3.45–4.44 = high (H), 4.45–5.00 = very high (VH).

Table 4
CEAs' perceived level of CSA extension delivery.

S/No A	Increase in productivity and income	Mean	Std. Dev.
	Increase in cocoa yields	4.50	.680
	Increase in food and crop security	4.51	.680
	Reduced cost of cocoa production	4.50	.680
	Reduced venerability to poverty	4.50	.680
	Modernized cocoa marketing chain	4.47	.718
	Total increase in productivity and income	4.5	.682
S/No B	Building resilience to climate change	Mean	Std. Dev.
	Collaborated with other climate change advocacy organizations	4.51	.680
	Educated farmers on climate change resilience strategies	4.50	.680
	Influenced farmers' socio-cultural backgrounds to climate change	4.50	.680
	Facilitated farmers' adaption of suitable climate-resilient strategies	4.50	.680
	Built farmers' capacity to mitigate climate change drawbacks	4.48	.690
	Total building resilience	4.5	.681
S/No C	Reduction in greenhouse gases emission	Mean	Std. Dev.
	Reduced emission of greenhouse gases in farmer cocoa fields	4.52	.670
	Developed carbon appropriation strategies in cocoa farm fields	4.50	.680
	Reduced vulnerability to changes in crop	4.49	.690
	Practicalized conservation agriculture in cocoa production	3.51	.788
	Reduced deforestation on cocoa farm fields	3.36	.903
	Total reduction in greenhouse emission	4.08	.701

Source: Field Data, 2022. n = 152. Scale: 1.00–1.44 = very low (VL), 1.45–2.44 = low (L) 2.45–3.44 = moderate (M), 3.45–4.44 = high (H), 4.45–5.00 = very high (VH).

Table 5
Correlation matrix of MPA extension delivery and CSA.

Independent variables	Correlation Coefficient (r)	Sig (p)	Type of Correlation	Strength of Relationship
Age (X_2)	−.193*	.017	Biserial	low
Years of experience (X_3)	−.351**	.000	Spearman's rho.	Moderate
Knowledge (X_6)	.359**	.000	Biserial	Moderate
Skills (X_7)	.359**	.000	Pearson	Moderate
Frequency of phone use (X_8)	.681**	.000	Pearson	Substantial
Duration of phone use (X_9)	.483**	.000	Pearson	Moderate
Funding (X_{10})	.807**	.000	Pearson	Very high

Source: Authors' Construct, 2022.

Table 6
Collinearity diagnostic test.

Independent Variable	Tolerance	VIF	Durbin Watson
Sex (X1)	.700	1.000	
Age (X2)	.996	1.004	1.9
Years of experience (X3)	.963	1.038	
Level of education (X4)	.600	1.000	
Extension Zone (X5)	.996	1.004	
Knowledge (X6)	.866	1.155	
Skills (X7)	.866	1.155	
Frequency (X8)	.375	2.664	
Magnitude (X9)	.940	1.063	
Funds (X10)	.843	1.186	

Source: Field Data, 2022. n = 152.

entry to analyze the data using the Software Package for IBM SPSS version 21.0 for analysis. This is because, OLS is considered a very robust regression method (Shah and Goldstein, 2006). Additionally, the step-wise method is a type of automated variable selection technique that aims to find the optimal subset of independent variables for a multiple regression model. The main advantage is its ability to capture the complex and multifaceted nature of real-world phenomena and individual independent variable contributions. The main disadvantages are the difficulty in interpreting and communicating the results especially where there are many independent variables or complex interactions (Smith, 2018). Table 7 shows the OLS regression of the level of MPA extension delivery components on CSA. The components of the MPA that predicted the operationalization of CSA in the research were funds, magnitude, knowledge, and years of experience which explained 72.9% of the influence of MPA extension service on climate-smart agriculture as shown by the R-squared (R^2) column. Individually, funding (X_{10}) gave (63.0%) explanation, the magnitude of the use of MPA procedures by CEAs contributed (3.9%) knowledge in the use of mobile phones for M, Agricultural extension delivery purposes accounted for (3.0%) and level of education of CEAs contributed (3.0%) as exemplified in the adjusted R-Square change (AdjR^2 Change) column.

Regression equation (from unstandardized Beta)

$$Y = a + \beta_{10} X_{10} + \beta_9 X_9 - \beta_6 X_6 - \beta_3 X_{3+} \mathcal{E} \quad (3)$$

$$Y = 1.764 + .498X_{10} + .292X_9 \text{ -}.177X_6 \text{ -}.052X_{3\,+} \mathcal{E} \quad (4)$$

$$Y = 1.764 \text{ if } \beta_2 = \beta_8 = \beta_{12} \quad (5)$$

Where, Dependent Variable (Y) = CSA a = constant, Ɛ = Error term.

X_{10} = Funds for use, X_9 = Magnitude of use, X_6 = Knowledge of use X_3 = Level of Education.

4. Discussion

This section discusses the results of the study. The first part presents and discusses the findings on CEAs demographic characteristics. The second part is CEAs perceived level of MPA in Ghana's cocoa sector. The third part is CEAs perceived funding in the use of mobile phones. The fourth part also discusses the level of climate-smart agricultural extension delivery during the Covid-19 pandemic. Again, Relationships between MPA extension delivery and climate-smart agricultural practices, a collinearity diagnostic test and OLS regression of MPA extension delivery on CSA practices were discussed.

4.1. Demographic characteristics of CEAs

The study reveals a gender disparity within CEAs, with a higher representation of males compared to females. Akpotosu et al. (2017) found in their study on extension workers in Ghana, that most extension employees were males, owing to the gender divide in public services. This implies that women are still underrepresented in the extension profession as observed by Armstrong et al. (2018). The age range (21–40 years) indicates that the majority of CEAs are likely in the early to mid-career stage of their professional journey. This stage is often characterized by gaining experience, building expertise, and developing a foundation for long-term career growth. This observation is in line with Anumaka and Ssemugenyi (2013) who found that most knowledge workers were between the ages of 20 and 39. The high percentage of respondents (80%) with bachelor's degrees or higher indicates the significance of educational qualifications in the CEA profession. Advanced education can contribute to professionalism, specialized knowledge, and the ability to address complex challenges, which is consistent with Ahmadpour and Soltani (2012), who found that 78% of extension workers in Iran had a bachelor's degree or higher. The range of experience indicates a mix of both relatively newer professionals and those with more extensive backgrounds, creating a diverse pool of knowledge

Table 7
Ordinary least squares regression of MPA extension delivery on CSA practices.

Predictors	Step of Entry	Beta(β) (unstandardized)	R^2	Adj R^2	AdjR^2 Change	S.E. E	F. Change	F. Sig*
Funds X_{10}	1	.498	.630	.627	.630	.18,496	180.702	.000
Magnitude X_9	2	.292	.670	.663	.039	.17,567	12.510	.000
Knowledge X_6	3	−.177	.699	.690	.030	.16,844	10.203	.000
Education X_3	4	−.052	.729	.718	.030	.16,069	11.282	.001

Source: Field Data, 2022. n = 152. *$p < 0.05$.

and perspectives within the extension workforce. The finding is in agreement with Akpotosu et al. (2017), who found that most extension agents' working experience in Ghana ranged from 1 to 20 years.

4.2. CEAs perceived level of MPA in Ghana's cocoa sector

Table 2 shows that the acquisition, conversion, application, protection, and distribution procedures for MPA were all high, with only little differences in CEA responses. This means that CEAs see these procedural processes of using mobile phones for CSA information acquisition, conversion, application, protection, and dissemination as an integral part of MPA extension delivery in the bridging of the information asymmetry among cocoa farmers. These procedures were further ranked as being high enough to contribute to cocoa growers' access to information. Acquisition, according to Gbosien and Ugo (2021) is the capacity (of CEAs) to identify, access, and gather the internal and external knowledge required for organizational tasks that enhance the pool of information accessible to the organization, allowing stakeholders to make better choices more quickly, which is critical for higher performance. This implies that CEAs by the process of acquisition use their mobile phones to gather the knowledge required for stakeholders to make informed CSA choices. Zaky and Soliman (2017) emphasized the importance of the knowledge conversion process, stating that it allows organizations to improve expertise and efficiency by translating acquired knowledge into applicable organizational knowledge and disseminating it to where it is needed. Thus, by the process of conversion, CEAs with the aid of their mobile phone interpret CSA practices necessary for a better harvest. Knowledge application is the integration of acquired knowledge into an organization's products, processes, and services to maintain a competitive advantage (Akram and Hilman, 2018). CEAs by the process of application use their mobile phone to facilitate the process of farmers putting CSA knowledge to use. Again, protecting knowledge within an organization from illegal, inappropriate use or theft both inside and outside, according to Zaky and Soliman (2017) is an important security measure for every organization in encouraging knowledge sharing and use. CEAs use their mobile phone to aid knowledge protection processes which preserve the inimitable quality of knowledge and ensure competitive advantage. The distribution process aids in the timely transmission of information to stakeholders and thereby, facilitates the achievement of the organizations' intended goals (Gbosien and Ugo, 2021). The process of distribution using mobile phones helps to connect both CEAs and farmers in knowledge interactions, developing information, improving knowledge management, and typically engaging in the knowledge production process of proper CSA practices on cocoa farms. Hence the high rate of CSA information acquisition, conversion, application, protection and distribution by CEAs via mobile phones is crucial for stakeholder awareness, and willingness to adopt and practice CSA strategies.

Table 2 further revealed that knowledge, skill, frequency, and magnitude in mobile phone usage were high, with little variance in CEAs replies. This means that CEAs estimated they have the requisite knowledge, skills, and resources needed to effectively utilize mobile phones in MPA to enhance the use of contemporary technology, inputs, and best practices to facilitate the spread of CSA information. Completing a job like sending, retrieving, and storing information through a cell phone needs appropriate expertise (Darwin, 2003; Goldman, 2017). CEAs by their use of mobile phones apply a set of skills and mindsets that help to disseminate and solve CSA problems through novel solutions. According to Cooley et al. (2016) to preserve knowledge, one must have present visible competence in terms of abilities to perform a taught behaviour including the relationship between mental activity and physiological commands gained by experience or education through observing, and finding, or learning. Thus, CEAs' perception of their ability, their expectations of future success, and the extent to which they value an activity influence their motivation and persistence, leading to improved outcomes even in a technologically influenced era (Haste, 2018). Thus, the creation of an enabling environment for improvement in knowledge, skill, frequency, and magnitude of use of mobile phones by CEAs is a necessary aspect of the successful implementation of MPA.

4.3. CEAs perceived funding in the use of mobile phone

The total perceived contribution of funding to the implementation of MPA for CSA information delivery by the CEAs in mobile phones rated very high implying that CEAs acknowledge that enough funds were provided for purchasing airtime and maintaining phones for CSA activities. This assertion is in direct contrast to Ankrah et al. (2022) who indicated that decentralized government agencies including the Department of Agriculture (DoA) remain underfunded by the government of Ghana. Yet in the case of COCOBOD, private sector actors, NGOs, and Development Partners remain visible in funding the implementation of the CSA program. This is confirmed by the CEAs rating of point four (4) as being high in the results Table 2 stated as "Cocoa boards' ability to get support in the form of funding from other stakeholders for CSA activities". An increase in financial support to stakeholder project stakeholders increases their probability of adopting new technologies (Wolfert et al., 2017). Furthermore, CEAs stated that they got financial support from other stakeholders for CSA activities. Efforts to continue piloting projects are in no way taken seriously in most developing countries, as in most cases, farmers are unwilling to finance the services as they believe that the state must provide agricultural extension assistance (Wolfert et al., 2017). Indeed, extension delivery has remained largely public in most developing countries. Oino et al. (2015) asserted that getting support from other stakeholders will help organizations attain project sustainability since most agricultural projects are financed by donors.

4.4. CEAs perceived level of climate-smart agricultural extension delivery during the Covid-19 pandemic

CEAs considered CSA to be high enough in terms of increasing productivity and income, building climate resilience, and reducing greenhouse gas emissions to help achieve a positive organizational goal of assisting farmers in reducing vulnerability, increasing adaptive capacity to climate change, and better coping with ex-post risk. Increased food, and crop security, collaboration with other climate change advocacy organizations, and reduced emission of greenhouse gases in farmer cocoa fields were the resultant effect of the use of mobile phones for the dissemination of CSA. This result is in line with Verhagen et al. (2014) report that, CSA ensures food security and contributes to development. Again, FAO's State of FAO (2013) report, showed that increasing productivity and lowering costs via enhanced resource-use efficiency are important ways to achieve agricultural development. The report further explained that, to eliminate poverty and enhance food security countries must ensure agricultural development with a high proportion of the population reliant on agriculture.

CEAs asserted that educating farmers from varying demographic backgrounds in mitigating climate change impacts to increase climate change resilience provides a conceptual justification for improving agricultural adaptation and mitigation practices to help food security in a changing environment. According to Carmona et al. (2015), people's sociocultural backgrounds, economic status, and personal behaviour influence CSA adoption. For smallholder farmers in developing countries, yield gaps, or the difference between what they achieve on their farms and what is technically possible, are significant and therefore, adapting to new ways to cope with climatic difficulties, according to Warner et al. (2015), will provide a conceptual underpinning for improving agricultural adaptation to help build farmers' capacity to mitigate climate crises.

CEAs considered their effort of reducing greenhouse gas emissions via MPA to be high enough to contribute to the achievement of a positive organizational goal of assisting farmers in reducing vulnerability, increasing adaptive capacity to climate change, and better coping with ex-post risk. Xu and Shang (2016) indicated that lowering Co2 emissions is possible but requires effort in reducing emissions from fossil fuels such as coal, natural gas, and oil, as well as deforestation and land cultivation, which promotes the breakdown of soil organic matter and crop and animal residues. CEAs' involvement in growth interventions that focuses on agricultural intensification and agricultural product market channel renovation facilitates increased agricultural production, poverty reduction and meeting rising food demand (Loayza and Raddatz, 2010; Wolfert et al., 2017) as advocated by the CSA principle of farming.

4.5. Relationships between MPA extension delivery and climate-smart agricultural practices

The positive and very high significant relationship between Climate Smart Agricultural information dissemination and funding for phone use implies that, for CEAs to be able to effectively use MPA to disseminate CSA information, adequate funds are a necessity. Access to, use of, and need for ICT tools helps agro-enterprises run and manage their outfit (World Bank, 2007) and all these activities requires money to buy data, phone, and maintain the phone.

Again, the positive and moderately significant relationship between Climate Smart Agricultural and Knowledge, Skills, frequency of use, and magnitude of phone use is indicative of the fact that CEAs' knowledge, skills, frequency of phone use, and magnitude of phone use for MPA activities influenced the extent to which climate-smart information delivery was practised in Ghana's cocoa sector as measured during the Covid-19 period. Tall et al. (2014) collaborate on these results saying that, after labour, land, and capital, competencies such as knowledge, skills, frequency, and magnitude of use of technology are considered the fourth production feature, especially in the agricultural where making appropriate information accessible to the farming community in a timely and well-packaged form helps boost output, productivity, and profits of stakeholders.

The negative and moderate significant relationship between Climate Smart Agricultural activities and years of experience and a negative and low significant relationship between Climate Smart Agricultural and age is suggestive that older and more experienced CEA are less enthusiastic about MPA in comparison to their younger counterparts. These findings align with Akpotosu et al. (2017) who concluded that online proficiency decreases with age and years of experience since younger extension employees utilize the internet more than experienced extension workers, and younger CEAs exhibit better internet competency than older CEAs. Jones et al. (2022) further indicated that job experience tends to impact job performance and conduct negatively, as age progresses for knowledge workers who stay longer in a particular work outfit.

4.6. Collinearity diagnostic test

According to Bosompem et al. (2013), the Variance Inflation Factor (VIF) shows how much the variance of the coefficient estimate is being inflated by multicollinearity. VIF close to 10 is a cause for worry, yet a tolerance closer to 1 indicates no collinearity while a tolerance value of zero (10) indicates a severe multicollinearity problem. Thus, no multicollinearity was found among variables, since the VIF test showed no variable with a VIF value greater than 10 (Bosompem et al., 2013). Autonomy of residuals was assumed since the value of the Durbin-Watson test for the models was 1.9 falling within the accepted range of 1.89–2.03 (Panda et al., 2021).

4.7. Ordinary least squares regression of MPA extension delivery on climate-smart agricultural practices

The first overall best predictor funding is implicative of the fact that money should be provided for Mobile Phone Agricultural activities because farmers' ability to use CSA procedures on their farms is directly influenced by agricultural extension delivery objectives of spreading CSA knowledge, which enhances farmers' performance in adopting, reducing, and resisting shocks and vulnerabilities connected with climate change. Thus, most of the activities necessary for the attainment of a positive effect of MPA on CSA require the judicious use of financial resources in both effective and efficient ways. According to Andrea et al. (2021), companies will successfully gain a competitive advantage in the long term if they develop knowledge at a cheaper cost and faster rate and use funds effectively and efficiently to improve up-to-date goods. Ansah and Siaw (2017) asserted that excellent organizational capital management contributes to an organization's capacity to perform better advantageously.

Further, the magnitude of the use of MPA procedures implies that CHED has better positioned itself to create an enabling environment that encouraged CEAs to use MPA extension delivery methods to advance the course of CSA even in the face of adversity such as the COVID-19 pandemic. According to Mills and Smith (2011), competitive advantage and superior performance can only be achieved if proper management is used to remove barriers between the human resource and the organization's available information, allowing individuals to use this information for innovation and productivity. Cooley et al. (2016) added that the magnitude of capacity demonstrated by individuals (such as the use of a mobile phone) for a specific organizational purpose (such as CSA) can be incorporated into the firm's knowledge base to help boost productivity, profitability, and thus organizational performance.

Again, knowledge of the use of mobile phones for mobile phone agricultural extension delivery purposes means that CEAs ability to seek information outside the organization and create new knowledge through the interplay of new and old knowledge directly impacts CHED's ability to expand its knowledge base and, as a result, increase performance about the spread of CSA information. Cooley et al. (2016) emphasized that knowledge permits the recording of on-the-job observations that may be used to establish expert directories to stimulate knowledge sharing via human-to-human interactions by the use of ICT-enabled gadgets such as mobile phones. Andrea et al. (2021) researched to explore the association between knowledge management capabilities and organizational performance and discovered that knowledge is positively associated with organizational performance. However, in the face of a lower level of workforce diversity in terms of sex, age, and educational levels among knowledge workers, knowledge application may have a negative influence on job performance (Jones et al., 2022).

Also, CEAs' level of education influences their ability to apply CSA information delivery strategies by agricultural extension. Jones et al. (2022) found that education was related to task performance and helps people perform better in most knowledge work jobs. However, working at levels designated below a person's educational aptitude demotivates knowledge workers and negatively impacts their performance (Jones et al., 2022).

The limitation of the study is related to the use of Ghanaian CEAs working in the public sector for testing the hypothesis. Although the results of this study are cautiously generalizable to the CEAs in other backgrounds, using a hand full number of Ghanaian CEAs who operate in a developing country under specific circumstances, limits the generalizability of the results to other frameworks especially to a developed country context. Hence, the level of efficacy of MPA capacity in the study is delimited to the opinions of CEAs about their performed tasks as stipulated by CHED in Ghana. As more data become available, researchers may consider other external governance mechanisms, such as the labour, farmer demographics and corporate control markets. Methodologically, more insights may be obtained by future studies by conducting in-depth interviews with regional managers, district officers and other shareholders apart from CEAs.

5. Conclusions

The study sought to explore findings on CEAs' perceived level of MPA in Ghana's cocoa sector, CEAs' perceived contribution of funding in the use of mobile phones, the level of CSA extension delivery during the Covid-19 pandemic, the relationships between MPA extension delivery and CSA practices, and influence of MPA extension delivery on CSA practices. Using cross-sectional data, based on the responses of 152 CEAs in the Ashanti Region, the level of MPA, the contribution of funds and the level of CSA practices in the study area were found to be high.

The study found a significant relationship between CSA and MPA extension delivery services in that, there was a positive and very high significant relationship between CSA extension delivery and funding for phone use, a positive and moderate significant relationship between CSA extension delivery and knowledge, skills, frequency and magnitude of phone use, a negative and moderate significant relationship between CSA extension delivery and years of experience and a negative and low significant relationship between CSA extension delivery and age. The best predictors of CSA practices contingent on the components of the MPA extension delivery included funds, the magnitude of the use of MPA procedures, knowledge, and years of experience giving (72.9%) explanation of the effect of MPA extension delivery on the level of CSA in Ghana's cocoa sector during the Covid-19 pandemic.

The novelty lies in its examination of the effectiveness of mobile phone agriculture in extension delivery and its relationship with climate-smart agricultural practices specifically during the Covid-19 pandemic in Ghana's cocoa sector. It addresses the limited literature on mobile phone usage in extension delivery during the pandemic and identifies factors such as knowledge, skills, and funding that influence climate-smart agricultural activities facilitated by mobile phone extensions.

The theoretical implications of the findings contribute to the existing knowledge by highlighting the positive correlation between mobile phone agriculture extension delivery and climate-smart agricultural practices. This expands the understanding of the role of mobile phones in extension services during the pandemic and their impact on sustainable farming practices. The study also identifies factors such as knowledge, skills, and funding as influential in promoting climate-smart agricultural activities facilitated by mobile phone extensions, thereby enriching the theoretical framework in this domain.

In practical terms, the findings have important applications for real-world settings, particularly in the cocoa sector of Ghana and other countries. The identification of the positive relationship between mobile phone agriculture and climate-smart practices suggests that leveraging mobile phone technologies can effectively enhance agricultural extension services during challenging circumstances like the Covid-19 pandemic. The study emphasizes the need to enhance the capacity of community extension agents, especially in reaching underserved cocoa communities, to effectively utilize mobile phone agriculture for disseminating climate-smart agricultural information. Furthermore, the insights on factors like knowledge, skills, duration, frequency, and financial investments provide practical guidance for policymakers and organizations interested in adopting mobile phone agriculture for innovative extension services in climate-smart agriculture. These findings highlight the importance of investing in training, knowledge transfer, and infrastructure development to facilitate the effective use of mobile phones in delivering climate-smart information to farmers. By considering these factors, stakeholders can promote sustainable farming practices and mitigate the negative impacts of climate change on agricultural productivity and resilience through the application of mobile phone technology.

6. Policy recommendations

The findings of this study lend support to the self-efficacy theory which states that the "belief in one's capabilities to organize and execute the course of action required to produce given accomplishments" influences a person's choices, actions, the amount of effort they give, their perseverance when faced with obstacles, their resilience, their thought patterns and related emotional reactions, and the final level of achievement. This paper has important policy implications for countries that are currently or contemplating the intensive use of MPA for innovative extension delivery of CSA activities to take into consideration creating an enabling environment that facilitates knowledge, skills, duration, frequency, and financial investments in the acquisition, conversion, application, protection, and distribution of CSA information. By these parameters, this paper introduces new components for assessing MPA to test the hypothesis of a unique data set from Ghana toward mitigating the negative effect of climate change by the application of climate-smart information. It was found that to effectively apply MPA extension delivery in the transfer of CSA information, government, donors, and development partners pay more attention to the overall best predictor (funds) by committing more financial and logistical resources to boost agricultural productivity and reduce associated risk and unforeseen situations to arrest climate change shocks and stress particularly in the period of pandemics. It is suggested that CHED should tighten the working relationships that exist with organizations interested in undertaking interventions to minimize overlaps to ensure farmers break free of climate change-induced stress, shocks, and vulnerabilities. The study further recommended among others that CHED should train more CEAs to improve information delivery, consolidate and increase the gains made even with the disadvantaged CEA-to-farmer ratio. The government of Ghana should provide adequate incentives to motivate CEAs to put more effort into their MPA extension delivery services to ensure food security in Ghana.

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Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.indic.2023.100274.

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