Adoption Determinants of Agricultural Extension Communication Channels in Emergency and Non-emergency Situations in Ghana

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Abstract: The determinants of agricultural extension communication channel usage depend on several factors but have not been explored in the context of emergency (Fall Armyworm outbreak) and non-emergency situations. A multistage purposive sampling technique was used to select 318 farmers, focusing on the districts and the communities with the highest reported cases of fall armyworm infestation. Descriptive statistics and a multivariate probit analysis were used in the analysis of the data. The results showed an increase in the intensity of channels’ usage in the emergency situation. It was also found that fertilizer and improved seeds were the most common extension need. Channels are found to be more complementary in the emergency case. In both situations, some factors explaining the choices of these channels varied, while others agreed. The study recommends multiple channels are made available and that time-consuming channels irrespective of their effectiveness should be avoided by extensionists in emergency situations.

Keywords: fall armyworm; agricultural extension; communication channels; multivariate probit; emergency; non-emergency

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PUBLIC INTEREST STATEMENT

Agricultural extension has often been studied under the assumption that farmers face the same situation; its impacts on productivity, income, welfare, as well as the choices farmers make in the usage of extension communication channels. There are various channels through which farmers can decide to access their extension services. The channels used by farmers are vital information needed by extensionists to effectively target their clients. The study focused on what determines farmers’ usage of these extension communication channels in different situations in the Northern region of Ghana. The 2017/2018 farming season was the first time Ghana experienced a large-scale outbreak of fall armyworm which devastated crops especially maize. This was compared with the subsequent year (2018/2019) which did not experience an outbreak. It was found that farmers’ choices varied in those two situations (emergency and nonemergency). A study like this would help extensionists vary their approaches when situations changes.


1. Introduction
The contribution of agricultural extension to agricultural development and food security has never been doubted (Pan et al., 2018). In the broader sense, the roles agricultural extension plays are technical, marketing, organizational, and entrepreneurial roles in the agricultural sector (Rivera, 2001). Following these strategic roles extension plays in agriculture, it can be concluded that an economy like Ghana’s whose dependence on agriculture cannot be overemphasized has so much to gain from an improved agricultural extension system. As of 2016, the agricultural sector contributed more than 20% of Ghana’s Gross Domestic Product (GDP) and employed about 36% of the total labour force. It engages more than 70% of the labour force in the rural areas of the country (World Bank, 2018).

Essentially agricultural extension involves the process of providing information and advisory services that are required and demanded by farmers to bring about a change and improve the lives of farmers and their communities (Christopoulos, 2010). The information from the extensionist to the farmer has to be communicated through a channel, hence the role of agricultural extension communication. This is defined as the transfer of an idea, advice, or information to a farmer through various channels, with the hope of influencing his or her decision (Kurtzo et al., 2016). Agricultural extension communication like all forms of communication has four elements; source, message, channel, and the receiver (Bidireac et al., 2015). The source in the context of agriculture is mostly the agricultural extensionists, while the receiver is basically the farmer. This study focuses on the channel of communication which is the means through which the message gets from the source to the receiver (Akinbile & Otitolaye, 2008).

According to Okwu et al. (2006), for effective communication, the transfer of information from the source to the receiver should face little or no distortions. Following the elements of communication mentioned above, the distortion of the message or otherwise would most likely be determined by the channel it follows to the receiver. This implies that the channels through which this information passes through are as important as the information itself. Channels of communications are numerous and dynamic. Hence, there is no single channel that fits with all situations.

These channels are basically divided into two: non-interpersonal (Radio, television, phone calls, posters, newspapers, meetings, film shows, internet, social media, etc.) and interpersonal (extension agent, contact/lead farmers, opinion leaders, friends and family, field demonstrations, etc.) communication channels (Licht & Martin, 2007; Okwu et al., 2006). The choice of a communication channel is dependent on the cost, availability/accessibility, and suitability of the channel, nature of the message, and the farmer’s expectation or preference (MoFA (Ministry of Food and Agriculture), 2011). The Directorate of Agricultural Extension Services (DAES) under the Ministry of Food and Agriculture (MoFA) is responsible for all aspects of agricultural extension in Ghana (Ekepi & African Union, Semi-Arid Food Grain Research and Development (AU-SAFGRAD), 2013). The study incorporated the use of these channels in the context of a crisis or emergency compared with a normal situation.

1.1. The concept and the problem
Many extension approaches in Ghana have been top-down; that is, extensionists know better than farmers in terms of technical knowledge for increasing productivity (MoFA (Ministry of Food and Agriculture), 2011). The choice of communication channel and all other related activities of the extension delivery process are done by those offering the service (mostly the central government in the case of Ghana). However, Rivera and Qamar (2003) have observed that a combination of top-down and bottom-up approaches results in a more efficient extension delivery services. In light of this, this study approaches the use of channels of communication from the farmers'
perspective. Extension agents, with this knowledge, can carefully adopt and integrate communication strategies and channels to each local situation for efficient delivery (Akinbile & Otitolaye, 2008).

Agricultural extension in Ghana as a whole is faced with financial, infrastructural, and human resources constraints (World Bank, 2018). In the case of developing countries, not only is the funding to this sector limited, it has been dwindling in recent years (Okorley et al., 2010). These constraints translate into the poor extension agent to farmer ratio of 1:1300 in Ghana (Anang et al., 2020). Even though this is the national ratio, the World Bank (2018) noted that farmers in the Northern Regions as compared with the Southern Regions receive inadequate extension services, indicating that this ratio is worse for the study area. This was corroborated during the launch of the Ghana Extension Systems Strengthening Project (GESSiP), where it was mentioned that “In the Northern Region, there is a low extension worker to farmer ratio of one worker to 2,300 farmers, far lower than the national average ...” (Citinewsroom, 2020). This, therefore, calls for a choice of a channel that is mostly used or preferred by the farmers given the limited resources to that sector. Furthermore, there is a tendency of alienating some target audience of an extension exercise if they do not patronize the channel of communication (Bailey et al., 2014; Licht & Martin, 2007). This will give extensionist the information on farmers’ extension needs and their choice of extension communication channels. This concept of providing extension services based on the needs and priorities of farmers is known as demand-driven extension (Kilelu et al., 2014).

The study further included the concept of crisis communication, where different methods, channels, and messages are adopted in crises or emergencies. A crisis consists of any harm-inducing occurrences in the form of tsunamis, earthquakes, wildfires, industrial accidents, etc. (Seeger, 2006). In the era of frequent impacts from climate change, crises that used to be rare are now becoming more frequent especially in the agricultural sector. Therefore, these situations have to be factored into the operations of agricultural extensionists. Agriculture in Africa and Ghana for that matter has intermittently faced crises of various forms; the severe drought and famine of 1981–1983 (Dei, 1988; Tan & Rockmore, 2018), the locus outbreak in 1928 to 1931 (Batten, 1967; Lean, 1931), bush fire outbreaks (Addai et al., 2016; Korem, 1985) and more recently, the 2017–2018 outbreak of fall armyworm (Agboyi et al., 2020; Tambo et al., 2019; Williams et al., 2019). It is normally under these situations that the already resource and logistic strained extension service delivery is overwhelmed.

The fall armyworm is a migratory pest that was first reported in 2016 in Benin, Nigeria, and Togo, and got to Ghana in 2017 (Agboyi et al., 2020). The pests seriously compromise the yields of maize which is already below its potential in Ghana. The pest attacks the maize plant at all stages; destroying the leaves of the young plants and burrowing into the cobs of fully grown and matured maize plants (Tambo et al., 2019). In this regard, the intensity of the yield loss becomes a function of level and timing of infestation, pathogen levels, the growth stage of the maize crop, and the health and vigour of the maize plant (Williams et al., 2019). In the specific case of Ghana in 2017, Day et al. (2017), estimated a 45% mean loss of maize (i.e. 824,300 tons), which translated into a mean loss of 278.65 million US Dollars.

Maize farmers are chosen for two reasons; firstly, it the most widely grown cereal in terms of both planting area and output in the region, with over 90% of the output consumed by farmers households (Abukari & Alemdar, 2019). Secondly, it is the primary target of fall armyworm since it is the only crop the pest can attack at any point in its vegetative growth (Montezano et al., 2018).

The channels of communication used or preferred by farmers in emergency and non-emergency situations have to be known by extensionists to focus their message through some channels to increase the efficiency of their service delivery in both situations. The study there considered the 2017/2018 outbreak of fall armyworm in the Northern Region as the emergency and the 2018/2019 farming season as the non-emergency situation.
2. Methodology

2.1. Sampling
A multistage purposive sampling procedure was used in arriving at the final respondents used for the study. At the level of the districts, three (3) districts (Savelugu/Nanton, East Gonja, and the West Mamprusi) were purposively selected, because they recorded the highest number of reported cases. Four (4) highly infested communities were selected in each of these districts; Savelugu/ Nanton (Sahakpaligu, Sahanauyili, Savelugu, and Pong-Tamale), East Gonja (Sispe, Kabache No.2, Masaka, and Fiu), and West Mamprusi (Mimima, Boayini No. 2, Boayini No. 1 and Zanguga). The inclusion of any farmer in this sample has two criteria to meet; their maize farms would have to be infested in the 2017/2018 season and at the same time, he or she should have cultivated maize in the 2018/2019 season. Because of this, a snowballing sampling technique was applied in selecting the farmers from these communities to a tune of 318.

2.2. Variables
Not all the communication channels were used because some were either not available in the study area or those interviewed did not use them. In all eight (8) channels (five non-interpersonal and three interpersonal) were used in the study area. These were radio, television, phone calls, posters, internet for the non-interpersonal, and workshops, extension agents, lead and colleague farmers, for the interpersonal communication channels. The study is underpinned by the random utility maximization theory which suggests that a rational farmer would choose a communication channel over another only if the probability of the utility from that channel is greater than or equal to the alternative.

There are two categories of factors that combine to influence a farmer to decide on the use of any communication channel. First is the characteristic of the said channels and the second are the socio-economic characteristics of the farmers involved. The first categories of variables considered in this study are accessibility (This measures whether a said communication is accessible within the reach of the farmer. It also includes whether they have the gadget needed for that channel), cost (This measures whether farmers consider the cost/opportunity cost associated in using the said communication channel), regularity (This measures whether farmers consider how often information can be accessed through a particular communication channel), language (This refers to whether the language used by the channel determines the choice of the channel by a farmer) and trust (This measures the level of perception on whether a farmer trust the information from a particular channel). The second category consists of the gender of farmer, marital status, education, household size, and experience in farming, electricity, pest information needs, off-farm, and monthly income. The availability of electricity in an area is suspected to influence farmers’ usage of a communication channel since some of them depend directly or indirectly on electricity. If pest and disease management is part of a farmer’s information needs for seeking extension services, then the choice of a channel may be influenced in these two situations; this is captured by the pest information needs variable.

2.3. The multivariate probit model
The use or otherwise of a communication channel is a binary choice; hence, a probit or logit model could fit such a dependent variable. However, since the study is dealing with eight (8) possibly correlated channels, a multivariate form is needed, that is, a multivariate probit (MVP) or a multivariate logit (MVL). The possible correlation of the use of these channels is proven in many literatures (Licht & Martin, 2007; Shetty, 1969, 544). While different distributional assumptions are underpinning these models, they generally produce very similar results. Some have proclaimed the superiority of the probit model for not invoking the controversial Independence of Irrelevant Alternatives (IIA) assumption of the logit models (Kropko, 2008). On this same basis, this study adopts the MVP.

The general specification for the MVP is given as:
\[ Y_k = \beta_k X_k + \alpha_k A_k + \epsilon_k \]  

\[ Y_k \] is the latent dependent variable for the \( k \) number of communication channels. \( \beta_k X_k \) and \( \alpha_k A_k \) are the vectors independent variables that influence the choice of these channels. The \( Xs \) are the inherent characteristics of the choices, while the \( A \)s are those factors or the characteristics of the individual making these choices. Equation 2 establishes the relationship between latent variables \( (Y_k) \) in Equation 1 and the observed variable \( (Y_{ik}) \)

\[
\{ \begin{align*}
Y_{ik} & = 1 \text{ if } Y_k > 0 \\
Y_{ik} & = 0 \text{ if otherwise }
\end{align*} \]  

(2)

Zero \( (0) \) is the cut-off point beyond which, the value of the observed \( (Y_{ik}) \) takes 1, otherwise zero.

According to Chib and Greenberg (1998), given the response function \( Y_{ik} \), the Multivariate Normal (Gaussian) Distribution is given as:

\[ f_X(x_1, x_2, \ldots, x_n \mid \mu, \Sigma) = \frac{1}{(2\pi)^{n/2} |\Sigma|^{1/2}} \exp \left( -\frac{1}{2} (x - \mu)^T \Sigma^{-1} (x - \mu) \right) \]  

(3)

From these equations \( Y_k \) and \( \beta \) still represent the latent variable and the vector of unknown regression coefficients. \( \Sigma \) is the variance-covariance matrix of \( Y_k \), the \( \mu \) is the mean. The \( \Sigma \) which is normally expressed as a vector of rhos \( (\rho) \) represent the pairwise correlation coefficient of the channel usages.

2.4. Empirical model

With eight \( (8) \) communication channels (unobserved dependent dichotomous variables) which are influenced by fourteen \( (14) \) variables, and assuming the error term in Equation 1 is Multivariate Standard Normally (Gaussian) distributed, then the eight \( (8) \) univariate probit models that would be solved simultaneously are as follows:

\[ Y_{rad,-1} = \beta_{rad} X_{rad} + \alpha_{rad} A_{rad} + \epsilon_{rad} \quad Y_{rad} = 1 \text{ if } Y_{rad} > 0, \text{ otherwise, } 0 \]  

(4)

\[ Y_{tel,-2} = \beta_{tel} X_{tel} + \alpha_{tel} A_{tel} + \epsilon_{tel} \quad Y_{tel} = 1 \text{ if } Y_{tel} > 0, \text{ otherwise, } 0 \]  

(5)

\[ Y_{cal,-3} = \beta_{cal} X_{cal} + \alpha_{cal} A_{cal} + \epsilon_{cal} \quad Y_{cal} = 1 \text{ if } Y_{cal} > 0, \text{ otherwise, } 0 \]  

(6)

\[ Y_{pos,-4} = \beta_{pos} X_{pos} + \alpha_{pos} A_{pos} + \epsilon_{pos} \quad Y_{pos} = 1 \text{ if } Y_{pos} > 0, \text{ otherwise, } 0 \]  

(7)

\[ Y_{wsh,-5} = \beta_{wsh} X_{wsh} + \alpha_{wsh} A_{wsh} + \epsilon_{wsh} \quad Y_{wsh} = 1 \text{ if } Y_{wsh} > 0, \text{ otherwise, } 0 \]  

(8)

\[ Y_{int,-6} = \beta_{int} X_{int} + \alpha_{int} A_{int} + \epsilon_{int} \quad Y_{int} = 1 \text{ if } Y_{int} > 0, \text{ otherwise, } 0 \]  

(9)

\[ Y_{ext,-7} = \beta_{ext} X_{ext} + \alpha_{ext} A_{ext} + \epsilon_{ext} \quad Y_{ext} = 1 \text{ if } Y_{ext} > 0, \text{ otherwise, } 0 \]  

(10)

\[ Y_{col,-8} = \beta_{col} X_{col} + \alpha_{col} A_{col} + \epsilon_{col} \quad Y_{col} = 1 \text{ if } Y_{col} > 0, \text{ otherwise, } 0 \]  

(11)

\( Y_{rad} = 1 \) if a farmer listens to the radio to seek extension service, otherwise 0, \( Y_{tel} = 1 \) if a farmer watches television to seek extension service, otherwise 0, \( Y_{cal} = 1 \) if a farmer makes phone calls to seek extension service, otherwise 0, \( Y_{pos} = 1 \) if a farmer uses phone as means of seeking agricultural extension information, otherwise 0, \( Y_{wsh} = 1 \) if a farmer attends agriculture-related workshops, otherwise 0, \( Y_{int} = 1 \) if a farmer uses the internet to seek information relating to his or her farming, otherwise 0, \( Y_{ext} = 1 \) if a farmer relies on agricultural extension agents for information on their farming activities, otherwise 0, \( Y_{col} = 1 \) if a farmer relies on colleague farmers for information on their farming activities, otherwise 0.
For all the communication channels, the following equation expresses all the possible correlation coefficients ($\rho$):

\[
\begin{pmatrix}
\varepsilon_1 \\
\vdots \\
(X-MVN) \\
\varepsilon_8
\end{pmatrix} = \begin{pmatrix}
0 & \rho_{11} & \rho_{12} & \rho_{13} & \rho_{14} & \rho_{15} & \rho_{16} & \rho_{17} & \rho_{18} \\
\rho_{12} & 0 & \rho_{22} & \rho_{23} & \rho_{24} & \rho_{25} & \rho_{26} & \rho_{27} & \rho_{28} \\
\rho_{13} & \rho_{23} & 0 & \rho_{33} & \rho_{34} & \rho_{35} & \rho_{36} & \rho_{37} & \rho_{38} \\
\rho_{14} & \rho_{24} & \rho_{34} & 0 & \rho_{44} & \rho_{45} & \rho_{46} & \rho_{47} & \rho_{48} \\
\rho_{15} & \rho_{25} & \rho_{35} & \rho_{45} & 0 & \rho_{55} & \rho_{56} & \rho_{57} & \rho_{58} \\
\rho_{16} & \rho_{26} & \rho_{36} & \rho_{46} & \rho_{56} & 0 & \rho_{66} & \rho_{67} & \rho_{68} \\
\rho_{17} & \rho_{27} & \rho_{37} & \rho_{47} & \rho_{57} & \rho_{67} & 0 & \rho_{77} & \rho_{78} \\
\rho_{18} & \rho_{28} & \rho_{38} & \rho_{48} & \rho_{58} & \rho_{68} & \rho_{78} & 0
\end{pmatrix} \pm \frac{1}{2}
\]

(12)

The rhos could be positive or negative, which means that some communication channels could be used together or some could be used in place of others, that is complementarity and substitutability of channels, respectively. The main diagonal of the correlation matrix are all ones, that is, $\rho_{11} = \rho_{22} = \rho_{33} = \rho_{44} = \rho_{55} = \rho_{66} = \rho_{77} = \rho_{88} = 1$. The off-diagonal rhos are symmetrical to each other, which means only one part of it is needed. For example, $\rho_{18} = \rho_{18}'; \rho_{71} = \rho_{71}'; \rho_{28} = \rho_{28}$. However, since the study is dealing with two case scenarios, the other unwanted diagonal would be replaced with the correlation matrix of the other scenario to conserve space.

Given the fact that farmers normally use more than one channel in accessing their agricultural information, the study is interested in the probability of farmers using all the eight channels as well as not using any of them. This is revealed by the joint probability of success and the joint probability of failure, respectively (Roussas, 2014). Furthermore, the unconditional probability of a farmer using any of the eight (8) channels irrespective of his or her choice of other channels is estimated using the marginal probability of success, i.e. a farmer choosing a particular channel (Roussas, 2014). It is expected that this measure would reflect the same results as the percentage of farmers using these channels.

3. Results and discussion

3.1. Extension information needs

As seen in Table 1, seeking information on fertilizer and improved seeds are the highest while marketing and Farmer Based Organizations (FBOs) recorded the lowest. The government’s flagship program, Planting for Food and Jobs (PFJ), which is accessible to all farmers concentrates on the provision of fertilizer and improved seeds (AGRA (The Alliance for a Green Revolution in Africa), 2019). This is expected to change if another program is implemented with a different focus.

| Information Need              | Total | Percent(%) |
|-------------------------------|-------|------------|
| Improved seeds                | 160   | 50.31      |
| Fertilizer and its application| 194   | 61.01      |
| Pest and weed control         | 94    | 29.56      |
| Farm credit                   | 70    | 22.01      |
| Storage and post-harvest loses| 34    | 10.69      |
| Marketing of produce          | 31    | 9.75       |
| Farmer organization            | 17    | 5.35       |
The subsistent nature of maize farming and agriculture could explain the low patronage of marketing information from extension services. FBOs lack organizational skills to keep them beyond the purpose for which it was formed, hence the lack of interest in it by farmers. This information is relevant for extensionists who want to embark on a demand-driven extension service. However, cognizance must be taken to the effect that these needs vary from communities to communities, across crops and animals cultivated, and more importantly its non-static nature over time (Elly & Epafra Silayo, 2013).

3.2. Channel usage and intensity

Table 2 summarizes the eight (8) communication channels that were used by the farmers in the sample in both situations.

Except for workshops, there was an increase in the use of all communication channels in the emergency compared with the non-emergency case. Since this scale of outbreak was a shock to most farmers, it was normal that they would seek control remedies from various sources, hence the increase. Workshops normally take long hours and sometimes days, and farmers under the emergency situation cannot afford the luxury of time to patronize them. Extension agents and colleagues farmers are the most used channels in both situations enforcing the finding of Rodriguez et al. (2015) that the use of interpersonal communication channels has often overshadowed those of non-interpersonal in developing countries. In the specific area of agriculture, they found extension agents as the most preferred. Even though the finding of Melesse et al. (2018) was based on a different classification of communication channels (indigenous versus exogenous), the interpersonal ones were still dominant. Rodriguez et al. (2015) also support the finding that the radio has been the most preferred channel among the mass media channels of communication in all situations. It has also been observed that internet use is very low; illiteracy and the inadequate network could explain this phenomenon. Sobalaje and Adigun (2013) found the infrastructural challenge as the main constraint in the use of Information and Communication Technology (ICT) in general, which includes the internet.

3.3. Determinants of communication channel usage

3.3.1. Justification for MVP model

The correlation coefficients in Table 3 below the main diagonal represent those of the emergency and the ones above, the non-emergency situation. In the case of the emergency season, more than half of the combinations are significantly correlated. None of the communication channels in this context is negatively correlated. There is a mix of coefficients in the non-emergency case, that is, both negative and positive correlation coefficients. These correlations among the binary dependent variables in both situations justify the use of the MVP model.

| Table 2. Communication channel usage |
|--------------------------------------|
| Channels  | Emergency | Non-emergency |
|           | Frequency | Percent(%) | Frequency | Percent(%) |
| Radio     | 127       | 39.94      | 97        | 30.50      |
| Television| 104       | 32.70      | 66        | 20.75      |
| Colleagues| 144       | 45.28      | 95        | 29.87      |
| Posters   | 152       | 47.80      | 115       | 36.16      |
| Workshops | 42        | 13.21      | 93        | 29.25      |
| Internet  | 59        | 18.55      | 33        | 10.38      |
| Ext. Agents| 201      | 63.21      | 157       | 49.37      |
| Colleagues| 165       | 51.89      | 120       | 37.74      |
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Table 3. Correlation coefficients of channels

|         | Radio | Tele  | Calls | Posters | W.shops | Internet | E. Agents | Colleagues |
|---------|-------|-------|-------|---------|---------|----------|-----------|------------|
| Radio   | 1     | 0.032 | −0.134 | −0.172 | −0.081 | 0.043    | −0.067    | −0.037     |
| Tele    | 0.225 | 1     | −0.029 | −0.127 | −0.039 | 0.106    | −0.087    | −0.095     |
| Calls   | 0.084 | 0.174 | 1     | −0.162 | −0.042 | −0.042   | −0.095    | −0.04      |
| Posters | −0.073 | −0.01 | −0.061 | 1       | 0.092  | 0.087    | 0.121     | 0.13       |
| W.shops | 0.004 | 0.065 | 0.093  | −0.02  | 1      | −0.015   | 0.07      | 0.0414     |
| Internet| 0.272 | 0.305 | 0.232  | 0.078  | 0.077  | 1        | −0.109    | 0.054      |
| E.Agents| 0.116 | 0.0871| 0.052  | 0.169  | 0.105  | 0.045    | 1         | 0.101      |
| Colleagues | 0.156 | 0.081 | 0.004  | 0.128  | 0.06  | 0.217    | 0.192     |

* a, b, and c represent 10%, 5%, and 1% level of significance respectively.

Coefficients below the main diagonal represent emergency and those above, non-emergency situation.

3.3.2. Determinants of communication channel usage (emergency and non-emergency)
The results are discussed in order of factors relating to the characteristics of the channels and then socioeconomics factors relating to the farmers and their environment as in Tables 4 and Tables 5. To begin with, the 1% significance of the Wald Chi-Squared of 425.38 and 388.46 means a rejection of the hypothesis that the joint correlation of the coefficients in the model is zero, indicating the model fitted the data quite well in both situations.

According to Sobalaje and Adigun (2013), the accessibility of a channel is very important in determining its use. In terms of accessibility, the results show that farmers are less likely to use television and extension agents as a channel for extension information, but more likely to rely on posters in emergency situations. Television may not be accessible to most of the farmers because it requires the availability of electricity and ownership/access to a television set. This finding is corroborated by the work of Okwu and Daudu (2011) who found that the unavailability of television and extension agents was responsible for their low usage. Since most of them are off the national grid, they are less likely to use television if their usage of a channel is based on its accessibility. Furthermore, for those who have an electricity supply, it is luxury to many to own a television. These reasons are not expected to change with respect to an emergency; hence, this finding is reflected in both situations. The extension agent to farmer ratio is already very low in the country. This indicates that they are less accessible to farmers. Therefore, if the accessibility of a channel is a determinant in farmer’s usage, then the farmer should be less likely to consider extension agents as reflected in the results; they are expected to be scarcer in an emergency situation. The result in the non-emergency case is however not significant. The likelihood of using posters is high in both situations. Posters normally provide visual and illustrative information to farmers. These posters are often posted on walls or kept for a longer period. This makes them readily available and accessible at any time in any situation.

In terms of the cost of using a channel, farmers are less likely to use radio, poster, and colleague farmers, but are more likely to use phone calls. This is the case for both situations except that colleague farmer under non-emergency is not significant. A rational farmer would use a channel considered relatively less expensive. On that basis, none of the findings meets a prior expectation. It turns out that farmers are less likely to use the less expensive channels (radio, poster, colleague farmers) and are using the more expensive ones (phone calls). All things being equal, the usage of phone calls as a channel of communication is expected to be more costly than the use of radio.
Table 4. Determinants of communication channel usage (emergency situation)

| Variable          | Radio   | Tele    | Calls   | Poster   | W. Shop | Internet | Agents   | Colleagues |
|-------------------|---------|---------|---------|----------|---------|----------|----------|------------|
| Accessibility     | -0.005e | -0.442a | -0.038  | 0.431b   | -0.192  | 0.109    | -0.355b  | 0.078      |
|                    | (0.177) | (0.190) | (0.200) | (0.176)  | (0.212) | (0.206)  | (0.175)  | (0.165)    |
| Cost              | -0.994c | 0.068   | 1.399c  | -0.396c  | -0.017  | -0.106   | -0.092   | -0.511c    |
|                    | (0.220) | (0.232) | (0.228) | (0.199)  | (0.242) | (0.234)  | (0.195)  | (0.193)    |
| Regularity        | 1.143c  | -0.238  | 0.073   | -0.827c  | 0.292   | 0.336    | -0.380a  | 0.363b     |
|                    | (0.217) | (0.214) | (0.211) | (0.199)  | (0.245) | (0.235)  | (0.190)  | (0.182)    |
| Language          | 0.069   | -0.674c | -0.028  | 0.019    | -0.264  | 0.006    | -0.059   | 0.132      |
|                    | (0.212) | (0.217) | (0.229) | (0.210)  | (0.256) | (0.240)  | (0.209)  | (0.200)    |
| Trust             | 0.162   | 0.053   | -0.264  | -0.281   | -0.076  | 0.125    | -0.275   |           |
|                    | (0.179) | (0.198) | (0.203) | (0.183)  | (0.213) | (0.170)  | (0.172)  | (0.172)    |
| Income            | 0.223a  | 0.222b  | 0.142   | 0.133    | -0.062  | 0.089    | 0.064    |           |
|                    | (0.093) | (0.102) | (0.108) | (0.094)  | (0.111) | (0.091)  | (0.090)  | (0.090)    |
| Off Farm          | -0.093  | 0.248   | 0.284   | -0.073   | 0.475b  | 0.257    | 0.159    | 0.255      |
|                    | (0.190) | (0.207) | (0.191) | (0.223)  | (0.206) | (0.189)  | (0.185)  | (0.185)    |
| Gender            | -0.531  | -0.647  | -0.239  | 0.124    | -0.354  | 0.050    | -0.324   | -0.099     |
|                    | (0.369) | (0.529) | (0.405) | (0.376)  | (0.532) | (0.425)  | (0.345)  | (0.335)    |
| Marital Status    | -0.351  | 0.197   | 0.091   | -0.431   | 0.296   | 0.290    | -0.084   | 0.109      |
|                    | (0.280) | (0.334) | (0.328) | (0.281)  | (0.401) | (0.346)  | (0.270)  | (0.259)    |
| Education         | 0.287a  | -0.090  | -0.086  | -0.009   | 0.069   | 0.029    | 0.133    | 0.048      |
|                    | (0.170) | (0.186) | (0.189) | (0.170)  | (0.206) | (0.189)  | (0.164)  | (0.161)    |
| House Hold Size   | -0.011  | -0.019  | -0.042c | -0.021a  | 0.020   | -0.009   | -0.006   | -0.005     |
|                    | (0.012) | (0.013) | (0.014) | (0.013)  | (0.013) | (0.012)  | (0.011)  | (0.011)    |
| Experience        | 0.011   | 0.0005  | 0.014   | 0.013    | 0.014   | 0.006    | 0.003    | -0.008     |
|                    | (0.008) | (0.009) | (0.009) | (0.008)  | (0.009) | (0.009)  | (0.008)  | (0.008)    |
| Electricity       | 0.799c  | 1.287c  | 0.660c  | -0.910c  | -0.265  | 0.624    | -0.586c  | -0.487c    |
|                    | (0.206) | (0.241) | (0.212) | (0.192)  | (0.231) | (0.236)  | (0.190)  | (0.180)    |
| Pest Info. Needs  | 0.366b  | -0.057  | 0.088   | -0.018   | -0.329  | -0.137   | 0.007    | 0.127      |
|                    | (0.173) | (0.182) | (0.191) | (0.176)  | (0.224) | (0.197)  | (0.166)  | (0.164)    |
| Constant          | -2.421c | -1.647c | -1.628b | -0.836   | -1.319a | -2.995c  | -0.768e  | 0.012      |
|                    | (0.582) | (0.640) | (0.671) | (0.571)  | (0.712) | (0.673)  | (0.559)  | (0.540)    |

Log likelihood = -1229.6551; Wald Chi Squared (112) = 425.38; Prob > Chi Squared = 0.00; Number of observations = 318

a, b, and c represent 10%, 5%, and 1% level of significance respectively

The frequent use of dry cell batteries for radio sets especially in places without electricity could explain the higher cost relating to its usage. Also, these results could be possible if farmers view the cost variable in terms of opportunity cost.

In both situations, the regularity of a channel increases the likelihood of farmers using radio and otherwise for posters and extension agents. Programs on the radio are very regular at the time assigned to them. Farmers just need to tune in at the appropriate time. Radios are portable and mobiles making it a more regular source of information to farmers, whether at home or on the farms. In the case of extension agents, their availability does not mean they are a regular channel of information. Because of their scarcity, farmers would not be able to access them when they need them. Time and logistical challenges also explain why these agents are not regular in communities they are assigned. Colleague farmers were found to be a regular source of information in the emergency situation but were not significant in the non-emergency situation. Okwu and Daudu (2011) considered colleagues (Relatives, friends, and neighbours) as a very regular channel of communication hence their patronage. In an outbreak like armyworm, the most readily and regular channel of information is the colleagues from whom updates and prevention measures are sourced.
| Variable            | Radio     | Tele      | Calls     | Poster    | W.Shop    | Internet  | Agents    | Colleagues |
|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| Accessibity         | 0.213     | -0.437    | -0.305    | 0.702     | 0.168     | 0.314     | -0.078    | 0.165      |
|                     | (0.188)   | (0.206)   | (0.197)   | (0.200)   | (0.182)   | (0.251)   | (0.166)   | (0.171)    |
| Cost                | -0.815    | -0.096    | 1.518     | -0.631    | -0.187    | -0.291    | 0.052     | -0.152     |
|                     | (0.221)   | (0.265)   | (0.217)   | (0.217)   | (0.205)   | (0.279)   | (0.192)   | (0.194)    |
| Regularity          | 0.988     | -0.291    | 0.114     | -0.876    | -0.033    | 0.183     | -0.488    | -0.010     |
|                     | (0.221)   | (0.237)   | (0.236)   | (0.207)   | (0.196)   | (0.260)   | (0.188)   | (0.185)    |
| Language            | 0.070     | -0.679    | 0.141     | 0.226     | -0.222    | -0.124    | 0.025     | 0.021      |
|                     | (0.223)   | (0.227)   | (0.259)   | (0.224)   | (0.220)   | (0.273)   | (0.202)   | (0.207)    |
| Trust               | 0.510     | 0.172     | -0.305    | -0.217    | 0.009     | -0.334    | 0.054     | -0.232     |
|                     | (0.195)   | (0.215)   | (0.202)   | (0.190)   | (0.183)   | (0.216)   | (0.167)   | (0.170)    |
| Income              | 0.003     | 0.004     | 0.292     | -0.020    | 0.129     | 0.260     | 0.012     | 0.189      |
|                     | (0.120)   | (0.151)   | (0.151)   | (0.130)   | (0.118)   | (0.163)   | (0.115)   | (0.114)    |
| Off Farm            | -0.034    | -0.313    | 0.139     | 0.226     | 0.463     | -0.021    | 0.348     | 0.233      |
|                     | (0.169)   | (0.201)   | (0.186)   | (0.173)   | (0.161)   | (0.214)   | (0.153)   | (0.155)    |
| Gender              | -0.068    | 0.238     | 0.214     | 0.364     | -0.137    | 0.300     | -0.256    | -0.185     |
|                     | (0.367)   | (0.432)   | (0.394)   | (0.384)   | (0.369)   | (0.449)   | (0.344)   | (0.343)    |
| Marital Status      | -0.456    | -0.075    | -0.325    | -0.431    | 0.289     | 0.038     | 0.081     | 0.155      |
|                     | (0.284)   | (0.353)   | (0.316)   | (0.291)   | (0.289)   | (0.363)   | (0.258)   | (0.265)    |
| Education           | 0.450     | -0.227    | -0.234    | 0.019     | 0.001     | 0.151     | 0.167     | -0.025     |
|                     | (0.177)   | (0.207)   | (0.199)   | (0.182)   | (0.171)   | (0.219)   | (0.161)   | (0.164)    |
| House hold Size     | -0.009    | 0.0003    | -0.020    | -0.005    | 0.024     | 0.002     | -0.011    | 0.004      |
|                     | (0.013)   | (0.013)   | (0.014)   | (0.014)   | (0.012)   | (0.015)   | (0.012)   | (0.012)    |
| Experience          | 0.014     | -0.010    | 0.009     | 0.009     | 0.012     | 0.004     | 0.003     | -0.005     |
|                     | (0.008)   | (0.010)   | (0.009)   | (0.009)   | (0.008)   | (0.010)   | (0.008)   | (0.008)    |
| Electricity         | 0.711     | 1.556     | 0.295     | -1.106    | -0.858    | 0.547     | -0.648    | -0.681     |
|                     | (0.211)   | (0.336)   | (0.216)   | (0.203)   | (0.192)   | (0.277)   | (0.181)   | (0.179)    |
| Pest Info. Needs    | 0.357     | -0.093    | 0.326     | 0.026     | -0.074    | -0.105    | 0.079     | 0.016      |
|                     | (0.177)   | (0.195)   | (0.197)   | (0.188)   | (0.182)   | (0.229)   | (0.164)   | (0.170)    |
| Constant            | -2.031    | -0.849    | -2.512    | -1.516    | -3.245    | 4.090     | -1.021    | -0.213     |
|                     | (0.835)   | (0.978)   | (0.973)   | (0.800)   | (1.099)   | (0.768)   | (0.765)   |             |

Log likelihood = -1224.9651; Wald Chi Squared (112) = 388.66; Prob > Chi Squared = 0.00; Number of observations = 318

a, b, and c represent 10%, 5%, and 1% level of significance respectively.

Farmers who consider the language with which the channel transmits the information are less likely to watch television in both situations. There are four major ethnic groups in the region under study; Gjonjas, Dagombas, Konkonbas, and Mamprusi. However, there are currently only two television stations (NTVand STV) in the region that uses more Dagbani than the other three. This means most of the farmers in the sample would have to rely on television that do not use their local language as a means of broadcast, hence the less likelihood of using it for agricultural extension purposes.

When it comes to the trustworthiness of the information that goes through a channel, farmers are less likely to rely on the internet under the emergency situation. Those who access the internet come across varieties of information, which are sometimes contradictory, and do not mostly apply in their agricultural context. There is also a rising phenomenon of fake news which becomes prominent in emergency situations. In the non-emergency case, farmers are more likely to trust information from radio stations. This could be because the radio has been the trusted source of information on most issues including agricultural extension.
On the factors relating to the farmers and their environment, richer farmers in times of emergency increase their usage of radio, television, and internet, while they only rely on phone calls and colleague farmers in normal times. All these channels, except colleague farmers, require the use of a gadget to access them (radio set, a television, a mobile phone and/or a computer). Normally, people without enough income cannot use these channels in any situation as reflected in the finding.

Access to electricity influences the usage of all but one in both situations. In both situations, it increases the likelihood of farmers using radio, television, phone call, and the internet, except that, phone call under non-emergency is not significant. Some channels are directly related to the availability of electricity, others are indirect, and some do not require it at all. In the era of Information and Communication Technology (ICT), the source of energy to power its accompanying devices is very important. This means that access to electricity exposes farmers to additional channels of communication. This finding has therefore proven that those with access to electricity are more likely to use the electricity-dependent channels (radio, television, phone calls, and internet) compared with their less likelihood of using channels that do not depend on electricity (posters, workshops, extension agent and colleague farmers).

The results of off-farm, education, household size, pest information needs, and experience did not meet a prior expectations.

3.3.3. Channel combination
Since the channels are used in a bundle, the relationship between these chosen bundles is revealed by the significant values of the rhos (covariance matrix) summarized in Table 6 for both situations. The rhos below the diagonal represent the emergency situation while that of the non-emergency represents those above the diagonal in the covariance matrix.

In the emergency situation, channels have been found to complement one another shown by the positive and significant rhos; Radio and television, radio and calls, radio and internet, radio and extension agents, radio and colleagues, television and internet, television and extension agents, television and colleagues, calls and posters, calls and internet, calls and extension agents, calls and colleagues, calls and internet, calls and extension agents, posters and internet, posters and extension agents, internet and colleagues, extension agents and colleagues. It is understandable that in emergencies, farmers would want to seek much information as possible from possibly different sources. Farmers may also seek information from various channels just to verify other information.

The non-emergency did not record many relationships between the usage of channels except in two cases; radio and calls, radio, and posters. In these cases, the rhos are negative and significant, indicating that these channels are being substituted for each other. Unlike the emergency situation, farmers have the luxury of using fewer channels to achieve their extension needs. This luxury extends to the fact that they have the chance to decide and substitute some channels for others.

For each of the supplementary statistics (marginal success probability and the joint probabilities), the values for non-emergency are in the upper rows while those of the emergency situation in the lower row. The joint probability of success in both emergency and non-emergency situations is 0.3% and 0.002%, respectively. This indicates that while it is nearly impossible for a farmer to use all the eight (8) channels at the same time in the non-emergency situation, there is a low possibility of that happening under the emergency situation. The case of the non-emergency is backed by the finding that farmers generally use less of communication channels and that there is no evidence of complementarity among the channel usage. This explains the near impossibility of jointly using all the eight (8) channels in that situation. The very low probability in the emergency situation stems from the fact that time and associated costs of using channels are limiting factors. Even though farmers would want to acquire more information from different channels in an emergency situation, time would not allow them, since every second count in the fight against the fall armyworms. The joint
probability of failure is also equally low for both situations indicating a very low possibility of a farmer not using any of the eight (8) channels. The probability is much lower in the emergency situation.

The marginal success probability for both situations mirrors the values and the explanation depicted in Table 1.

4. Conclusions and recommendations

In the era of demand-driven extension services, maize farmers in the region mostly need information on improved seeds as well as fertilizers and their application. The number or the intensity of agricultural communication channels under emergency situations is generally higher for all channels except the workshop. This indicates that channels that are time-consuming irrespective of their effectiveness should be avoided by extensionists in emergency situations since most farmers would not patronize it.

Extension agents who are the main and official channels of communication between MoFA and farmers have been found not to be accessible especially in an emergency situation, not a regular

Table 6. Covariance matrix (emergency and non-emergency situations)

|                   | Radio | Tele | Calls | Posters | W.shops | Internet | Agents | Colleagues |
|-------------------|-------|------|-------|---------|---------|----------|--------|------------|
| Radio             | 1     | 0.109 (0.112) | -0.188<sup>a</sup> (0.104) | -0.345<sup>c</sup> (0.099) | -0.139 (0.098) | 0.146 (0.118) | -0.037 (0.090) | 0.054 (0.092) |
| Tele              | 0.336<sup>c</sup> (0.096) | 1 | -0.027 (0.117) | 0.107 (0.117) | 0.055 (0.117) | 0.088 (0.136) | 0.147 (0.104) | 0.050 (0.106) |
| Calls             | 0.222<sup>b</sup> (0.100) | 0.171 (0.105) | 1 | 0.122 (0.107) | 0.113 (0.105) | -0.078 (0.126) | -0.143 (0.094) | 0.042 (0.097) |
| Posters           | -0.119 (0.097) | 0.105 (0.102) | 0.230<sup>b</sup> (0.096) | 1 | -0.124 (0.107) | 0.172 (0.118) | 0.085 (0.098) | 0.078 (0.099) |
| W.shops           | -0.007 (0.117) | 0.022 (0.115) | 0.181 (0.115) | 0.087 (0.120) | 1 | -0.014 (0.126) | -0.023 (0.094) | -0.039 (0.095) |
| Internet          | 0.436<sup>c</sup> (0.092) | 0.279<sup>c</sup> (0.103) | 0.208<sup>b</sup> (0.099) | 0.189<sup>a</sup> (0.101) | 0.145 (0.118) | 1 | -0.143 (0.106) | 0.158 (0.107) |
| Agents            | 0.269<sup>c</sup> (0.090) | 0.283<sup>c</sup> (0.099) | 0.243<sup>b</sup> (0.095) | 0.180<sup>a</sup> (0.093) | 0.104 (0.107) | 0.066 (0.104) | 1 | 0.096 (0.089) |
| Colleagues        | 0.189<sup>b</sup> (0.090) | 0.284<sup>c</sup> (0.093) | 0.194<sup>a</sup> (0.090) | 0.064 (0.093) | 0.083 (0.103) | 0.383<sup>c</sup> (0.093) | 0.278<sup>c</sup> (0.085) | 1 |
| Marginal success probability | 0.304 | 0.208 | 0.302 | 0.365 | 0.295 | 0.103 | 0.495 | 0.377 |
| Joint probability (success) | 0.399 | 0.327 | 0.449 | 0.483 | 0.133 | 0.187 | 0.636 | 0.522 |
| Joint probability (failure) | 0.00002 | 0.003 | 0.040 | 0.033 | 0.00002 | 0.003 | 0.040 | 0.033 |

Likelihood ratio test of rho21 = rho31\rho41 = rho51 = rho61\rho71 = rho81\rho32 = rho42 = rho52\rho62 = rho72 = rho82\rho43 = rho53\rho63 = rho73 = rho83 = rho54 = rho64 = rho74 = rho84 = rho65 = rho75 = rho85 = rho76 = rho86 = rho87 = 0:

Emergency: Chi Squared (28) = 112.061, Prob > Chi Squared = 0.0000
Non-emergency: Chi Squared (28) = 38.8577, Prob > Chi Squared = 0.0832

Coefficients below the main diagonal represent emergency and those above, non-emergency situation.

Marginal success probability and the joint probabilities: the values for non-emergency are in the upper rows and that emergency situation, in the lower row.

<sup>a</sup>, <sup>b</sup>, and <sup>c</sup> represent 10%, 5%, and 1% level of significance respectively.
source of information in all situations, less patronized in communities with electricity irrespective of the situation. Those who end up using it in the emergency normally complement it with other non-interpersonal channels like radio, television, calls, and posters, as shown by the covariance matrix. In practice, therefore, MoFA, through the DAES should focus on these other channels to complement extension agents in emergency situations.

Radio has shown to be a regular channel in all situations, most trusted in non-emergency, and highly patronized by educated farmers and communities with electricity for all situations. This still adds to the call for radio to be given much attention in an emergency situation since regular information is very important in emergency situations.

Television and the internet appear not to be good channels in both situations as farmers do not find them readily available as they pose a form of a language barrier for those who want to get agricultural information through them. They are patronized by farmers with higher incomes and farmers with electricity. The government through the National Communication Authority (NCA) can make a deliberate policy that allows more agricultural content to be delivered in local languages. But if the targeted area is without electricity, these channels should not be used irrespective of the situation.

Even though the use of workshops reduces in emergency situations, all the channel characteristics in the model did not favour its use even under the non-emergency situation. This calls for total avoidance of this channel in agricultural extension in the region, especially in emergency situations. MoFA can sensitize all actors in the agricultural sectors who intend to use this channel to shorten the amount of time, energy, and resources farmers would spend in participating. Posters are readily accessible to farmers but not a source of regular information for farmers in all situations. This means posters should be constantly updated on current issues, reprinted, and distributed widely within the time frame the information is needed by the farmers.

In the emergency situation, most channels are used to complement one another, as opposed to a non-emergency situation where farmers substitute some for the other. This calls for more channels to be made accessible in the emergency situation while focusing on the most used channels in the non-emergency situation. This should be done taking into consideration factors such as access to electricity.

The finding of the study affirms the fact that farmers’ choices of communication channels as well as what influences them in their choices differ in emergency and non-emergency situations. The recommendations mentioned above are therefore applicable to all emergency situations that directly affect the growth and health of crops similar to fall armyworms like severe drought, insect outbreak, bush fire, etc. However, for those emergency situations (famine, earthquakes, tsunamis, as well as pandemics like COVID 19) that do not directly affect the crops, these recommendations may not necessarily be applicable.

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