FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

The perceived effectiveness of agricultural technology transfer methods: Evidence from rice farmers in Northern Ghana

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Abstract: This study examined the effectiveness of various agricultural technology transfer methods using primary data collected from 543 rice farmers in the Northern and Upper East regions of Ghana. We employed descriptive statistics supported by Kendall's *W*-test and chi-squared distribution test to identify and assess various agricultural technology transfer methods and their perceived effectiveness. In the order of importance, we found farmer-to-farmer approach, technology demonstration fields, household extension, and radio as the main agricultural extension methods in use in the study area. We found a significantly low patronage of the mass media and Information and Communication Technology (ICT) mechanisms such as video, mobile phone, posters, drama, and newspapers for communicating information to rice farmers. Demonstration, farmer-to-farmer, and household extension methods were perceived as the most effective agricultural extension methods. We recommend among others, that Ministry of Food and Agriculture of Ghana should be empowered to train farmers through both

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PUBLIC INTEREST STATEMENT

There are several agricultural extension methods used to transmit information on improved agricultural practices to farmers. However, a number of factors could affect the effectiveness of the extension methods used by various actors in the technology transfer space. These could include the cost of the method, the type of farmer being targeted, the geographic location of the farmer as well as sociocultural and economic conditions of the farmers. We used data from a cross section of rice farmers in Northern Ghana and found the farmer-to-farmer approach and technology demonstration farms to be the main extension methods in use. ICT mechanisms for agricultural extension have not been explored fully in the study area. Also, development projects in the NGO sector are greatly augmenting the public extension service offered by the government of Ghana through the Ministry of Food and Agriculture of Ghana.

conventional (i.e. demonstration fields), and technology-led approaches using ICT and mass media such as video, mobile phones, and radio, since these methods have been found to be cost effective with significant impact on agricultural technology adoption decisions of farmers.

Subjects: Agriculture & Environmental Sciences; Sustainable Development; Urban Development; Economics and Development

Keywords: agriculture technology; extension methods; perception; rice farmers; Northern Ghana

1. Introduction

Technological change and adoption of improved production techniques are important steps in the development process of every agrarian economy. This is especially true for agricultural development in Sub-Saharan Africa, where crop output has largely been stagnant for many years due to a multiplicity of factors including poor adoption and use of improved production methods. In a sharp contrast, the green revolution has significantly improved grain yields for the last several decades in Asia (Nakano, Tsusaka, Aida, & Pede, 2018). Rice is considered to be one of the most promising cereal crops to achieve the African Green Revolution (Tsusaka & Otsuka, 2013). The domestic consumption of rice in Ghana is already surging above production levels, with an annual deficit of about 40% which is catered for by imports (Ministry of Food and Agriculture [MoFA], 2016).

To make improvements in the rice sector, agricultural technology transfer is necessary. According to Anandajayasekeram et al. (2008), agricultural extension is the delivery of relevant agricultural information and technologies to farmers. This results into the technology transfer model of agricultural extension, seen by many as the main purpose of agricultural extension. This is based on the premise that "modern" knowledge and/or information is transferred via extension agents to recipient farmers. Thus, agricultural extension is the conscious communication of information to help farmers form sound opinions and make good decisions on farming. Agricultural extension is also seen to be a human-centred endeavour aimed at changing or improving knowledge, attitude, practices, and skills through education and provision of other support services to farmers. According to Ackah-Nyamike (2007), agricultural extension empowers farmers with the requisite knowledge, attitude and practices for enhancing productivity and welfare. In other words, agricultural extension has a philosophy of helping people to help themselves. The traditional view of agricultural extension in developing countries was very much focused on increasing production, improving yields, training farmers, and transferring technology (Davis, 2008).

Extension delivery is primarily a government responsibility in Ghana, though many other actors are involved, including development partners and non-governmental organisations (Lamontagne-Godwin, Williams, Bandara, & Appiah-Kubi, 2017). There is a poor farmer access to extension staff (i.e. four to five million smallholder farmers for 3500 agricultural extension agents) in Ghana (McNamara, Dale, Keane, & Ferguson, 2014). The lack of access is compounded by extension agents' lack of funds for transport, further reducing extension worker access to farmers. Extension workers may identify and know the solutions to problems faced by the farmers, and yet may not be able to disseminate the solutions to the farmers due to lack of appropriate extension teaching methods for transferring agricultural technologies.

Agricultural technology transfer methods refer to the techniques used by an extension system as it functions, for example, demonstration, or a visit by an extension agent to a farmer. There are several methods used in extension work. Some of these include individual/household extension method, group method, and mass media method. None of these methods can be singled out as the best one as they all have some advantages and disadvantages. According to

Anandajayasekeram et al. (2008), the choice of a method depends on various factors such as the tenure system in the area, community organisation, and resources availability. For example, in an area where tenure is communal, or land management is based on communal efforts, a group approach is likely to be more effective than an individual approach. Meetings, field days, and approaches to schools may also be good options. Despite the importance of agricultural extension in communicating relevant information about improved production techniques to farmers, there are limited studies, to the best of our knowledge, that evaluate the effectiveness of the various agricultural technology transfer methods in Ghana. This paper therefore highlights the sources of information to rice farmers, and the perceived effectiveness of various agricultural technology transfer (extension methods) that are being used by the stakeholders of the agricultural extension delivery system in Northern Ghana.

The provision of agriculture extension and major support services for farmers in the form of physical infrastructure and research services in Ghana have been the preserve of the government since independence in 1957. However, with respect to agricultural credit, extension, and marketing services, there has been a mix of both public and private sector participation with public services declining in quantity over the period of structural adjustment programmes in the country beginning in 1983–2006 (Buadi, Anaman, & Kwarteng, 2013). Over this period, government's involvement in extension delivery to farmers declined, especially, with the present decentralisation policy that places various agricultural development units under the District Assemblies which are underfunded. The decline of government extension delivery led to an increased role for not-for-profit organisations such as non-governmental organisations (NGOs) in supporting farmers of which the Northern part of Ghana has had its fair share.

The rest of this paper is organised as methodology, results and discussions, conclusions and policy implications.

2. Methodology

2.1. The study area

The study was conducted in two out of the three Northern regions of Ghana (i.e. the Northern and Upper East regions). Basically, two climatic conditions occur in the northern part of Ghana: The rainy season which begins lightly in April and rises steadily to a peak in August/September, and gradually declines by October/November. There is also a dry season which occurs between November and April with a peak in February and also characterised by dry harmattan winds which engulf the whole region. The vegetation of the region is generally the Guinea savannah with its characteristic grass and trees. The biodiversity in tree vegetation used to be high, but now it is decreasing due to over exploitation. The major economic activity of the people is agriculture (combination of crop and animal husbandry) with most part of the region being rural. Presently, the agricultural sector employs the largest share of the economically active population the Northern and Upper East regions of Ghana. While about 70% of the estimated economically active rural population in the Northern region are employed by the agriculture sector, the case for the Upper East region is about 79% (Ministry of Food and Agriculture [MoFA], 2016). These values are far above the national average of 41.2% (Ghana Statistical Service [GSS], 2012). Among the several crops grown in the region are maize, millet, rice, yam, sorghum, groundnut, cowpea, and Bambara groundnuts. The hoe is the most important tool, but those who can afford, do use bullocks and tractor ploughing service for land preparation. The regions also have a high potential in animal production in Ghana (Ministry of Food and Agriculture [MoFA], 2016). The most predominant animals found in the area include cattle, sheep, goat, guinea fowls, fowls, and donkeys. While the crops are mainly grown for subsistence, the animals are mainly for cash and are mostly kept as an insurance or in-kind savings for the family. Over the years, the regions have been identified as among the poorest in Ghana, with poverty levels of about 50% and 44% in Northern and the Upper East regions, respectively (Ghana Statistical Service [GSS], 2014).

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2.2. Sampling method and sampling size

Rice farmers in the Guinea Savannah ecological zone of the Northern and Upper East regions constituted the population (N) for this study. The Ghana Living Standard Survey round 6 (Ghana Statistical Service [GSS], 2014) puts the number of households in the Guinea Savannah zone who produce rice as 296,489. We employed multistage sampling method to select the respondents from rice-growing communities in the two regions. In effect, a mix of sampling methods including purposive sampling, cluster sampling, and simple random sampling were used to select 400 rice farmers from the two strata (i.e. irrigation and rain fed ecologies) in 62 selected communities in 10 districts[1] based on Slovin's (1960) formular (see equation 1), which is used to calculate sample size when little information is available for the population (Ryan, 2013; Ariola, 2006). The sample was adjusted to 600 to cater for design effect because of the multiple stages of selection. Meanwhile, 543 out of the 600 questionnaires contained all the necessary information for the purpose of analysis.

$$n = \frac{N}{1 + Ne^2} \tag{1}$$

where n is the sample size, e is the margin of error (which is 0.05 with confidence level of 95%). N is the population of rice farmers, which is 296,489 for this study. By substitution, the sample size (n) is computed as 400. The study however adjusted this sample size to 600 to cater for some design effects that might have arises.

2.3. Analytical framework

The study employed descriptive statistics supported by chi-squared χ^2 distribution test and Kendall's coefficient of concordance to identify and assess the various agricultural technology transfer methods and their perceived effectiveness among rice farmers in Northern Ghana. A χ^2 test is any statistical hypothesis test in which the sampling distribution of the test statistic is a χ^2 distribution when the null hypothesis is true. The χ^2 tests are often constructed from a sum of squared errors, or through the sample variance. Test statistics that follow a χ^2 distribution arise from an assumption of independent normally distributed data, which is valid in many cases due to the central limit theorem. A χ^2 test can then be used to reject the hypothesis that the data are independent. The χ^2 test is used to determine whether there is a significant difference between the expected frequencies and the observed frequencies in one or more categories. The χ^2 distribution can assume the following:

Given that $X_1, \ldots, X_n$ are i.i.d. $N(\mu, \sigma^2)$ random variables, then

$$\sum_{i=1}^{n} (X_i - X^*)^2 \sim \sigma^2 X_{n-1}^2 \tag{2}$$

where

$$X^* = \frac{1}{n} \sum_{i=1}^{n} X_i \tag{3}$$

Kendall's W (also known as Kendall's coefficient of concordance) is non-parametric statistic (Corder & Foreman, 2009; Kendall & Babington, 1939). It is a normalisation of the statistic of the Friedman test, and can be used for assessing agreement among raters. Kendall's W ranges from 0 (no agreement) to 1 (complete agreement).

Suppose, that a number of people have been asked to rank a list of agricultural technology transfer methods or approaches, from most important to least important. Kendall's W can be calculated from these data. If the test statistic W is 1, then all the survey respondents have been unanimous, and each respondent has assigned the same order to the list of concerns. If W is 0, then there is no overall trend of agreement among the respondents, and their responses may be regarded as essentially random. Intermediate values of W indicate a greater or lesser degree of

unanimity among the various responses. While tests using the standard Pearson correlation coefficient assume normally distributed values and compare two sequences of outcomes at a time, Kendall's *W* makes no assumptions regarding the nature of the probability distribution and can handle any number of distinct outcomes. *W* is linearly related to the mean value of the Spearman's rank correlation coefficients between all pairs of the rankings over which it is calculated.

The null hypothesis of this test would be that there is independence of the rankings produced by all famers. This is a one-tailed since it only recognises positive associations between vectors of ranks. Basically, the Kendall's statistic can be computed as

$$S = \sum_{i=1}^{n} (R_i - R)^2 \tag{4}$$

where *S* is the sum of squares statistic over the row sums of ranks. Following these, the Kendall's *W* statistic can be obtained as (Kendall & Babington, 1939)

$$W = \frac{12S}{p^2(n^3 - n) - pT} \tag{5}$$

where *n* is the number of objects, *p* is the number of judges. *T* is a correction factor for tied ranks. Kendall's *W* statistic is an estimate of the variance of the row sums of ranks R_i divided by the maximum possible value the variance can take; this occurs when all respondents are in total agreement; hence $0 \leq W \leq 1$.

Legendre (2005) discusses a variant of the *W* statistic which accommodates ties in the rankings and also describes methods of making significance tests based on *W*. Legendre compared via simulation the Friedman test and its permutation version. Unfortunately, the simulation study of Legendre was very limited because it considered neither the copula aspect nor the *F* test. Kendall *W* is a rank-based correlation measure, and therefore it is not affected by the marginal distributions of the underlying variables, but only by the copula of the multivariate distribution. Marozzi (2014) extended the simulation study of Legendre by considering the copula aspect as well as the *F* test. It is shown that the Friedman test is too conservative and less powerful than both the *F* test and the permutation test for concordance which always have a correct size and behave alike. The *F* test should be preferred because it is computationally much easier. Surprisingly, the power function of the tests is not much affected by the type of copula.

3. Results and discussion

Kendall's *W*-test was employed to rank the main sources of information on improved agricultural technologies to the farmers as well as the technology transfer methods employed by stakeholders of the agricultural extension delivery system in Northern Ghana.

3.1. Sources of information on improved agricultural technologies

The results from Table 1 reveal that about 92% of the respondents received information on improved production techniques from colleague farmers, corroborating with Nakano et al. (2018). About 78% of the respondents received information from research institutions such as SARI and IITA. This revelation was not surprising as IITA and SARI continue to maintain research stations and experimental sites in the study area. Researchers from these institutions usually use lead-farmers who maintain and manage various experiments set out by the researchers. Field days are organised by these researchers, at which periods, they communicate relevant technologies to the farmers who attend. Also, about 77% of the respondents received information from NGOs such as IFDC Ghana and the Advance II project. About 76% of the farmers also received information through mass media such as radio, television sets, and via mobile phones. The least source of information to the farmers (about 52%) was found to be via government extension agents from the Ministry of Food and Agriculture (MoFA), and also through other bodies such as produce

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Table 1. Main source of information on improved agricultural technologies		
Source of information[a]	Freq. (Yes)	Percent
Colleague farmers	502	92.4
Researchers (e.g. SARI)	423	77.9
NGOs (e.g. IFDC)	420	77.3
Media (radio, TV, mobile phone etc.)	411	75.7
MoFA extension agents	283	52.1
Others (e.g. produce aggregators)	283	52.1
N = 543		

[a]This was multiple response, so farmers were allowed to choose as many as applied to them.
Source: Analysis of field data (2017).

aggregators. The deterioration of the public agricultural extension system in Ghana coupled with low government funding for the sector has led to poor farmer access to public extension staff, which currently stands at about five million smallholder farmers to 3500 agricultural extension agents in Ghana (McNamara et al., 2014).

Results of the Kendall's *W*-test of the main sources of information to farmers on improved agricultural technologies in the study area as shown by Table 2, reveal a low concordance strength (*W*) of 0.185. This was however significant at 1%, thereby allowing us to reject the null hypothesis that there was no agreement among the raters. NGOs came first in terms of ranking as the main source of information to rice farmers in the study area with a mean rank of 2.73. This was followed by information from colleague farmers with a mean rank of 2.91. Research institutions, MoFA Extension Agents, and the Mass media came third, fourth, and fifth, respectively with mean ranks of 3.08, 3.56, and 3.90, respectively. Other sources of information such as those from produce aggregators who normally engage rice framers on contractual basis came last with a mean ranking of 4.83. The activities of produce aggregators and market queens in the rice sector have seen steady improvements in the study area during the past few years, with much investment coming in from the aggregators in form of production capital and supply of rice varieties of interest

Table 2. Results of Kendall's *W*-test of main source of information on improved agricultural technologies to rice farmers					
Source of information	Mean Rank	Std. Dev.	Min	Max	Ranking
NGOs (e.g. IFDC)	2.73	1.75	1	6	1st
Colleague farmers	2.91	1.285	1	6	2nd
Researchers (e.g. SARI)	3.08	1.645	1	6	3rd
MoFA extension agents	3.56	2.143	1	6	4th
Media (radio, TV, mobile phone, etc.)	3.9	1.57	1	6	5th
Others (e.g. produce aggregators)	4.83	1.26	1	6	6th
N	543				
Kendall's *W*[a]	0.185***				
Chi-square	502.384				
df	5				

The ranking was done from 1 to 6, 1 being the most important, and 6 being the least important ranking.
[a]Kendall's Coefficient of Concordance.
***1% Level of significance.
Source: Analysis of field data (2017).

to rice farmers who are engaged by these aggregators on contractual basis. Buadi et al. (2013) found that aside the critical role of the NGOs in the trainings of farmers and transferring critical agricultural technologies for improved production, they were also involved in information support services to the farmers, input supply, credit provision, as well as the monitoring and evaluation of extension activities. The farmers generally perceived the services of the NGOs to be relevant to their operations and leading to improvements in their incomes and welfare.

A study of the information needs and information seeking behaviour of rural dwellers in Nigeria indicated agricultural information as one of their needs (Momodu, 2002). Farmers will often time, require information on "where to purchase fertilizers", "how to use them", information on pesticides, herbicides, storage, and improved varieties of crops. Momodu (2002) noted that this information can be made available to farmer via ICT tools such as mobile phones and radio and are able to transmit information in real time. Alemna and Sam (2006), however, noted a negative effect in the use of ICTs in the rural areas of Ghana because literacy rates are very low. The situation gets worse when it comes to computer literacy. There are fewer computer-literate personnel in the rural areas. On the other hand, if farmers are to make good use of ICTs, the staff who advise and train farmers need to have more knowledge and skills in ICTs. However, with the improvements in the literacy rate of Ghanaians in recent years (Ghana Statistical Service [GSS], 2014), the use of ICT tools for information dissemination to farmers has increased, with NGOs such as IFDC Ghana, farm radio international and Esoko employing mobile phones, video, and radio programmes to reach out to millions of Ghanaian farmers in the study area.

3.2. Agricultural technology transfer methods in Northern Ghana

This section discusses various agricultural technology methods that are being used to transmit information to farmers in the study area. The change agents who use these methods have been discussed in Section 3.1. The study identified four main agricultural technology transfer methods namely the household method, the mass media method, the school approach, and the farmer-to-farmer method. To assess the agreement among raters, again we employed the Kendall's *W*-test to rank the main agricultural technology transfer methods in the study area (see Table 3). The strength of concordance (*W*) was estimated to be 0.45 and significant at 1%, an indication that we could reject the null hypothesis that there was no agreement among the raters.

The results from Table 3 show that farmer-to-farmer approach was the main extension or agricultural transfer method in the study area, corroborating with Nakano et al. (2018). This approach was ranked first by the farmers with a mean rank of 2.8. Out of the two methods of technology transfer methods under the school approach, the farmer-led technology demonstration method came second with a mean rank of 3.04. The lecture method was ranked fifth with mean rank of 6.19. The household or individual extension method came third with a mean rank of 3.95. By this method, farmers get to know about information from household members who have come in contact with such technologies either by learning from colleague farmers or other extension systems. According to Aremu, Kol, Gana, and Adelere (2015), radio is one of the fastest and most powerful instrument of communicating with the masses of rural people and farmers. They noted also that radio was useful in reporting news, such as announcement of meetings, and disseminating new skills, production techniques, or new methods of production in agriculture that will ultimately improve the living standards of rice farmers. Although radio placed fourth (with mean rank of 4.32), it was found to be the most prominent agricultural technology transfer method among all the mass media extension methods among all the 11 identified methods/approaches.

Electronic and mass media mechanisms are strong platforms for the dissemination of knowledge, skills, and improved technology to rice farmers. Such media play influential roles in providing extension services, especially in view of the public extension agencies' ineffectiveness in providing the much-needed agricultural extension services to farmers (Baloch & Thapa, 2017), especially in the rural areas of Northern Ghana. Despite the development of technology

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Table 3. Results of Kendall's *W*-test of main agricultural technology transfer methods						
Technology transfer method/approach		Mean Rank	Std. Dev.	Min	Max	Ranking
Farmer-to-famer		2.8	2.008	1	10	1st
Household		3.95	2.484	1	10	3rd
School	Demonstration	3.04	1.864	1	10	2nd
	Lecture	6.19	2.494	1	11	5th
Mass media	Radio	4.32	2.8	1	10	4th
	Mobile phone	6.43	2.509	1	10	6th
	Video	6.88	2.46	1	10	7th
	TV	7.03	2.307	1	11	8th
	Drama	7.68	2.053	1	11	9th
	Posters	8.59	1.885	1	10	10th
	Newspaper	9.1	1.913	1	11	11th
N		543				
Kendall's *W*[a]		0.450***				
Chi-square		1258.622				
df		10				

The ranking was done from 1 to 11, 1 being the most important, and 11 being the least important ranking. The mean is measured on a 5-point Likert scale. The rank 5 being most effective and 1 being least effective.

[a]Kendall's Coefficient of Concordance.

***1% Level of significance.

and ICT as well as the mass media in Ghana in recent years, their use in disseminating of agricultural information is still low, especially in the study area. Majority of the mass media/ICT approaches to agricultural extension were ranked least by the farmers as being dominantly used by change agents to disseminate information on improved technologies. Out of all the mass media methods, newspaper and poster were the least ranked with 11th and 10th positions, respectively. TV and drama came eighth and ninth with mean ranks of 7.03 and 7.63, respectively. Surprisingly, mobile phone and video came sixth and seventh with mean ranks of 6.43 and 6.88, respectively, diverging from the finding of Fu and Akter (2016). Video screening has recently been used by many projects including the Feed the Future USAID-Ghana Agriculture Technology Transfer Project to train thousands of farmers in the Northern regions of Ghana because of its low cost and ability to transfer information to many farmers at the same time and at their comfort.

3.3. Effectiveness of agricultural technology transfer methods

In Section 3.2, we discussed the various agricultural technology transfer methods that are being used to transfer information to rice farmers in Northern Ghana. This section presents the perceived effectiveness of rice farmers about the various technology transfer methods in terms of influencing the adoption of improved rice production technologies. The perception of the farmers was measured on a 5-point Likert scale, 5 being most effective and 1 being the least effective. The computed mean values shown in Table 4 indicate the weight of the perception by the farmers about a particular technology transfer method.

All the extension methods except newspaper (with mean value of 1.74), had more than a 50% perception index of influencing rice farmers to adopt improved production techniques. The extension method that was most perceived by farmers to influence adoption was demonstration (with mean value of 4.51). According to Aremu et al. (2015) and Anandajayasekeram et al. (2008), it is possible to reach large numbers of farmers within a short time at minimal cost and with great impact, using the demonstration method. The disadvantages of the approach, however, is that

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Table 4. Perceived effectiveness of the technology transfer methods			
Method	Mean	Std. Dev.	Ranking
Demonstration	4.51	0.962	1st
Farmer-to-farmer	4.47	1.069	2nd
Household	3.59	1.433	3rd
Lectures	3.45	1.429	4th
Radio	3.38	1.574	5th
Video	2.91	1.689	6th
Drama	2.58	1.561	7th
TV	2.39	1.496	8th
Posters	2.21	1.324	9th
Newspaper	1.74	1.136	10th
Mobile phone	1.5	1.01	11th

N = 543. The mean is measured on a 5-point Likert scale. The rank 5 being most effective and 1 being least effective.
Source: Analysis of field data (2017).

some farmers who attend the demonstrations may not be decision-makers in their homes and so considerable time is needed before such farmers who attend demonstrations become influential in their homes or society. The farmer-to-farmer extension method was also perceived to have very high impact on adoption of improved rice production technologies (mean of 4.47). By this method, there is the provision of training by farmers to other farmers, usually, through the creation of a structure of farmer promoters and farmer trainers (Scarbourough, Killough, Johnson, & Farrington, 1997; Simpson, Franzel, Degrande, Kundhlande, & Tsafack, 2015).

Household extension method, class room lecture approach, and radio came third, fourth, and fifth with mean values of 3.59, 3.45, and 3.38 respectively. Although farmers perceived TV, video, drama, and posters to influence adoption, they had low perception index of less than 3.0, meaning they were less effective as compared to the others. The household or individual extension method is most effective for activities undertaken by or within the full control of the individual farmer or household. In this regard, discussion with the whole family highlights more problems, and more experience is brought to the discussion (Anandajayasekeram et al. 2008). However, the household or individual extension method is characterised by high cost in terms of time and transportation. Only a few farmers may actually be visited. Also, the area covered is small since all the effort is concentrated on a few farmers or households per given time.

4. Conclusion and policy implications
In this study, we examined the sources of information on improved agricultural technologies to farmers as well as the technology transfer methods in Northern Ghana. In the order of importance, we conclude that NGOs, colleague farmers, research institutions, MoFA extension agents, the mass media (video, TV, and mobile phones), and produce aggregators are the main sources of information on improved agricultural technologies to rice farmers in the study area. We also conclude that farmer-to-farmer approach, technology demonstration fields, household extension, and radio are the main agricultural technology transfer methods (extension methods) in use in Northern Ghana. There is a significantly low patronage of the mass media and ICT mechanisms such as video, mobile phone, posters, drama, and newspapers for communicating information to rice farmers in the study area. Farmers also perceived demonstrations, farmer-to-farmer, and household extension methods to be the most effective agricultural extension methods in the study area. Newspaper, poster, and TV are ranked the least in terms of effectiveness for communicating agricultural technologies to farmers. It therefore imperative that, the agricultural policies of Ghana should be aimed at empowering the MoFA, both technically and financially, to train farmers

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through both conventional- (i.e. demonstration fields), and technology-led approaches using ICT and mass media mechanisms such as video and radio since these mechanisms have proven to be effective disseminating information to farmers in real time.

Competing Interest
The authors declares no competing interests.

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Note
1. The selected districts are Builsa north, Kassena-Nankana West, Kassena-Nankana East, Bongo and Bolgatanga for the Upper East region, and Karaga, Gushegu, Tolon, Kumbungu, Central Gonja, and Savelugu-Nantong districts for the Northern region.

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