

Original Paper

Perception of Agricultural Extension Agents Towards the Performance of Project-Based Extension Delivery on Food Security in Ghana

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Received: 26 May 2023; Revised: 14 December 2023; Accepted: 23 December 2023

DOI: <https://doi.org/10.46676/ij-fanres.v4i4.177>

Abstract— Agricultural extension agents in Ghana's Upper East Region relied on project-based extension delivery services during the COVID-19 period. Using the perspectives of extension agents, this research looked at the effect of project-based extension delivery services on food security. A sample size of 144 agricultural extension agents from three distinct zones in the Region participated in this descriptive correlation research. Frequencies, percentages, means, standard deviation, correlation coefficients, and ordinary least square regression were used to analyse the data. In terms of effectiveness, efficiency, relevance, and economics, the project-based extension delivery service performed well. In terms of stability, food security was excellent. There was a favourable association between food security and efficiency, relevance, and economics. Economy, efficiency, and age explained 79% of the changes in food security. On the perceived degree of food security, there was a substantial difference between male and female agricultural extension agents. Food security had a significant impact on project-based extension delivery services. The Ministry of Food and Agriculture should provide enough logistics, training, and incentives for agricultural extension agents to enhance information delivery.

Keywords—COVID-19 era, extension agents, food security, project-based extension delivery

I. INTRODUCTION

Food and nutrition security is a prominent goal in the Sustainable Development Goals (SDGs), with Target 2 of Goal 1 aiming to "halve the number of people who are hungry". Food security is defined by the Food and Agricultural Organization (FAO) as "a situation in which all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life" [1]. According to [3], the significance of government in providing food security for its inhabitants was publicized at the United Nations' World Food Summit Pledge, when member nations' governments vowed to half the existing rate of food insecurity.

Smallholder agriculture helps to reduce rural poverty and food insecurity in Sub-Saharan Africa (SSA) because smallholder agriculture is a major tool for creating jobs, promoting human welfare, and ensuring political stability in rural areas [4, 47]. [5] postulated that agricultural extension may simultaneously relieve poverty and achieve food security by providing high-quality services to small-holder farmers. Agricultural extension plays a crucial role in safeguarding food security through the provision of education to farmers on the prudent utilization of farm inputs and the implementation of agricultural practices [48, 49].

Unfortunately, agricultural extension, on the other hand, has financial, infrastructure, and human resource limitations in SSA. According to [6], not only is the financing for the agricultural extension sector low in underdeveloped nations, but financing has also been diminishing in recent years. In Ghana, these impediments have resulted in a 1:1300 extension agent-to-farmer ratio in the Southern Regions [7] and the northern areas, there is a low extension worker-to-farmer ratio of 1:2300 [8].

In 2017, the government of Ghana launched a unique project known as Planting for Food and Jobs (PFJ) to solve the low extension worker-to-farmer ratio challenge by simultaneously relieving poverty and attaining food security. This initiative necessitated the use of the Project-based Extension method, which focused on increasing extension resources for a particular region within a set time frame [9] because the Planting for Food and Job initiative's major purpose was to "modernize the agricultural sector of the economy to increase food security, generate jobs, and alleviate poverty" [10].

Project-based extension delivery methodology is a linear extension model aimed at increasing production through the transfer of technology as instituted by government policy through the sourcing of outside innovations, which necessitates the hiring of promoters whose role is to extend knowledge and encourage farmers to adopt recommended technologies if the researched exterior knowledge corresponds to the farmer's problem and needs. This paper, therefore, tested the fundamental

assumption of project-based extension delivery, which is stated as "research corresponds to farmer's problem and thus extension delivery should be oriented towards technology supply to a targeted group for the achievement of project objectives. This paper sought to answer the following questions; (1) what is the perceived level of the project-based extension delivery with respect to effectiveness, efficiency, relevance, and economy, (2) what is the perceived level of food security in terms of accessibility, availability, utilization, and stability, (3) what is the relationship between the level of project-based extension delivery services and the level of food security (4) to what extent is the project-base based approach contributing to the eradication of hunger amid COVID-19.

II. METHODOLOGY

Ministry of Food and Agriculture (MoFA) offices are found in all three designated operational zones in the Upper East region of Ghana. The regions have already been stratified into three main operational zones; namely, Western, Central, and Eastern operational zones. For this study, all MoFA operational

zones in the Upper East were used. All the MoFA Agricultural Extension Agents (AEAs), i.e., one hundred and sixty-six (166) in the three (3) operational zones were included in the sampling frame obtained from the MoFA office. A simple random sampling technique was applied at the various operational zones to get individual AEAs to respond to the questionnaires. Employing the Krejcie and Morgan sampling table, for the given population of 166 AEAs in the three randomly sampled operational zones in the Upper East region, 144 AEAs are the corresponding representative sample size to answer the questionnaire. Thus, the sample size of the study was 144 AEAs.

TABLE I. SAMPLING TABLE

Zone	Population(N)	Sample population
Western	54	48
Central	55	48
Eastern	56	48
Overall	166	144

Source: Field Survey (2021)

TABLE II. ANALYTICAL FRAMEWORK

Domain	Data component	Instrument: measurement	Data analysis
Perceived level of the project-based extension delivery	effectiveness, efficiency, relevance, and economy	Structured questionnaire: Scale	Descriptive statistics: - Percentages, Frequencies, means, standard deviation
Perceived level of food security	accessibility, availability utilization and stability	Structured questionnaire: Scale	Descriptive statistics: - Percentages, Frequencies, means, standard deviation
Relationship between project-based extension and food security	project-based extension and composite food security	Structured questionnaire: Scale	Inferential Statistics: - Spearman rho, Point Biserial, Biserial Pearson correlation
Predictability of project-based extension on food security	project-based extension and composite food security	Structured questionnaire: Scale	Inferential Statistics: - Ordinary Least Square (OLS) regression used in a stepwise entry
Comparison of perceived level of food security among male and female AEAs	male and female AEAs perceived level of composite food security	Structured questionnaire: Scale	Inferential Statistics: - Independent T-test
Comparison of perceived level of food security among the three (3) extension zones	AEAs in the three (3) extension zones perceived level of composite food security	Structured questionnaire: Scale	Inferential Statistics: - One way ANOVA

Data collected from the field was organized, edited, coded, and entered for analysis using the Software Package for IBM SPSS version 21.0 for analysis. All hypotheses for significant differences and relationships were tested at the 0.05 alpha level. Frequencies, percentages, mean, and standard deviations were used to examine AEAs' perceived level of project-based extension delivery. Frequencies, percentages, means, and standard deviations were used to study AEAs' perceived level of food security. An Independent t-test was used to compare the

perceived effect of project-based extension delivery on food security among male and female AEAs. ANOVA was used to compare the level of perceived effect of project-based extension delivery on food security among the three operational zones in the region. Correlational coefficients (Pearson, Point Biserial, and Spearman rho) were run to examine the relationship between the perceived effect of project-based extension delivery on food security. To assess the best predictors of food security from the main components of project-based extension

delivery, ordinary least square regression analysis using the stepwise entry method was used. The regression equation was stated as:

$$Y = a + \beta_{10} X_{10} + \beta_8 X_8 - \beta_2 X_2 + \varepsilon \quad (1)$$

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

Where, Dependent Variable (Y) = Food Security a = constant ε = Error term X_{10} = Economy, X_8 = Efficiency, X_2 = Age. The analytical framework is presented in Table II (appendix 1).

III. RESULTS AND DISCUSSION

A. Demographic Characteristics of Agricultural Extension Agents

The demographic characteristics of AEAs in MOFA are shown in Table III. In terms of sex distribution, men made up the majority (72.2%) of the respondents, while females made up only 27.8%. The findings of the research support [11] that women are underrepresented in science-related occupations. Again, [12] argued that women are still under-represented in extension professions. The findings support [50] who argued that the majority of AEAs are males. Table III further shows that most of the respondents (75%) were between the ages of 21 and 40. In line with these findings, [13] discovered that most knowledge workers are between the ages of 20 and 39. Table III further revealed that little over half of the respondents (63.9 %) had bachelor's degrees or above, which is consistent with [14], who found that 78 % of extension workers had bachelor's degrees or higher. Table III reveals that the majority of AEAs (59.7%) have worked for 1 to 20 years, which is comparable with the results of [15], who reported that most extension agents had worked for 5 to 15 years. Table III further depicts the three AEA expansion zones in the research region to illustrate the proposal that extension agents need to be placed in subunits (zones) to assist in increasing the efficacy of extension delivery [16]. Table III reveals that most respondents (97.2%) worked in rural and peri-urban regions.

TABLE III. DEMOGRAPHIC CHARACTERISTICS OF AEAs

Variables	Categories	Frequency	Percentage
Sex	Male	104	72.2
	Female	40	27.8
Age	21-30	39	27.1
	31-40	69	47.9
	41-50	20	13.9
	51-60	16	11.1
Level of Education	Certificate	16	11.1
	Diploma	36	25.0
	Undergraduate Degree	80	55.6
	Postgraduate Degree	12	8.3
Years of Experience	1-10	58	40.3
	11-20	34	23.6
	21-30	26	18.1
	31-40	24	16.7
	41-50	2	1.4
Work Zone	West	48	33.3
	Central	48	33.3
	East	48	33.3
Place of Work	Rural	120	83.3
	Peri-urban	20	13.9
	Urban	4	2.8

Source: Field Survey (2021)

B. AEAs Perceived Level of Effectiveness, Efficiency, Relevance and Economy of Project-based Extension Delivery Services

As evidenced by the mean and standard deviation ($x=3.81$, $SD=0.761$), Table IV shows that the general evaluation of the efficacy of AEAs in influencing project-based extension delivery services was high, with minimal variances among respondents. It can therefore be concluded that AEAs in the study area were goal-oriented. Again, AEAs' high efficacy in extension delivery demonstrates AEAs' care for the project policy's success. Effectiveness, according to [17], is concerned with accomplishing a preset goal (planned accomplishments) and comparing the actual impact (the output obtained) to the anticipated impact (the objectives). Effectiveness guarantees that the expected outcomes, goals, aims, or policies have been met. The ability of AEAs to continuously inspire farmers was rated at a high level with few variations among respondents ($x=4.01$, $SD=1.128$). According to [18], AEAs must continue to inspire farmers by persuading them that they can do things for themselves, make choices, and break free from poverty. According to [19], for extension training to be successful, training must be a communication aimed at growing skills, changing behaviour, and enhancing competence; it must be targeted at a specific group, and it must concentrate only on what needs to be known.

TABLE IV. AEAs PERCEIVED LEVEL OF EFFECTIVENESS OF PROJECT-BASED EXTENSION DELIVERY SERVICES

Components of the Level of Effectiveness	Mean	Std. Dev.
Continuously inspire farmers	4.01	1.128
Collaborate with other stakeholders in extension delivery	3.94	0.817
Train farmers using a one-on-one method	3.83	1.182
Guide farmers using mass method	3.65	1.059
Teach farmers using group method	3.61	1.153
Overall Rating of Effectiveness	3.81	0.761

Source: Field Survey (2021)

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)

With a minor difference from the respondents, Table V shows that respondents judged the overall efficiency of AEAs to project-based extension delivery services as moderate ($x=3.41$, $SD=1.043$). This shows that AEAs exhibited their potential to execute and accomplish project objectives at a lower cost. Efficiency is defined as the ratio of inputs to output, guaranteeing that the greatest output of products and resources is obtained from the resources employed in their production at a lower cost. The ability of AEAs to achieve organizational goals at a lower cost of service provided ($x=3.45$ $SD=1.305$) as depicted by the fewer variations among respondents, was the most important contributor to the overall rating of effectiveness of AEAs influencing project-based extension delivery services. Organizations are efficient when they can create maximum output from any given set of inputs, resulting in maximum production at reduced unit costs. AEAs are functionally focused on educating farmers about product value addition to enhance earnings as compared to selling raw agricultural goods [20]. The potential of AEAs to improve service delivery timeliness at a low cost was likewise strong ($x=3.45$ $SD=1.181$), with

fewer variances across respondents as evidenced by the standard deviation.

TABLE V. AEAs PERCEIVED LEVEL OF EFFICIENCY OF PROJECT-BASED EXTENSION DELIVERY SERVICES

Components of Level of Efficiency	Mean	Std. Dev.
Achieve organizational goals at a reduced cost of service provided	3.45	1.31
Augment timeliness of delivery of service at minimal cost	3.45	1.18
Adopt goal changes at a minimal cost	3.44	1.14
Enhance task completion rate at a minimal cost	3.37	1.14
Increase farmers' output at a minimal cost	3.31	1.16
Overall Rating of Efficiency	3.41	1.04

Source: Field Survey (2021)

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)

The relevance of AEAs in influencing project-based extension delivery services is illustrated in Table VI. The findings suggest that AEAs are very relevant ($x=3.58$), with a little variance ($SD=0.77$) across the responders. This means that AEAs were in a better position to provide farmers with the relevant information and skills at the right time. According to [21], relevance is about ensuring that consumers are treated fairly and get the quality and quantity of services that they deserve. With a minor difference among the respondents, respondents ranked AEAs' ability to Communicate with clients ($x=3.77$, $SD=0.856$) as the top contributor to the relevance of extension delivery. According to [22], communication helps to accomplish project objectives and organizational goals by providing new information, skills, practices, and attitudes in ways that benefit stakeholders. Furthermore, with low variance in response, AEAs' capacity to incorporate gender concerns was assessed as a strong ($x=3.63$, $SD=1.007$) contribution to the relevance of AEAs in extension delivery. This emphasizes the importance of gender equality and equity in extension services. [23] drawing lessons from Pakistan, proposed that creative ways to boost women's economic prospects, training skills, literacy initiatives, and resource mobilization should be implemented within socially and culturally acceptable standards in research and project contexts.

TABLE VI. AEAs PERCEIVED LEVEL OF RELEVANCE OF PROJECT-BASED EXTENSION DELIVERY SERVICES

Component of Level of Relevance	Mean	Std. Dev.
Communicate with your clients	3.77	0.86
Integrate gender issues	3.63	1.01
Coordinate developmental efforts among stakeholders	3.59	1.08
Achieve organizational goals	3.58	1.04
Serve farmers satisfactorily	3.33	1.00
Overall Rating of Relevance	3.58	0.77

Source: Field Survey (2021)

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 VII reveals that respondents regarded AEA's potential to impact the economic element of project-based extension delivery services as strong ($x=3.50$, $std=.914$), with minor variances across respondents. This means that, by using

project-based extension delivery techniques, AEAs were able to accomplish high-level project objectives at a lower cost while maintaining the quality of service. The economy is defined as reducing the cost of resources needed for activity while maintaining quality [24]. The largest contributions to the economy were improving farmers' access to finance ($x=3.62$, $std=1.050$) and enabling farmers to procure inputs ($x=3.58$, $std=0.881$), with less variance across respondents. Extension information is critical for farmers' loan acquisition and usage. Via technology, innovation, input acquisition, market access, and initiatives for alternative livelihood development, extension is well-positioned to solve food insecurity and poverty. Farmer organizations and associations play a crucial role in encouraging the adoption of institutional technology among farmers because of extension agents' abilities to teach, link farmers to credit institutions, and make it easier for farmers to get inputs [25].

TABLE VII. AEAs PERCEIVED LEVEL OF ECONOMY OF PROJECT-BASED EXTENSION DELIVERY SERVICES

Component of Level of Economy	Mean	Std. Dev.
Improve farmers' access to credit	3.62	1.05
Facilitate input acquisition among farmers	3.58	0.88
Train farmers in food processing	3.55	1.20
Encourage alternative livelihood opportunities	3.43	1.19
Promote marketing strategies among farmers	3.31	1.39
Overall Rating of Economy	3.50	0.91

Source: Field Survey (2021)

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)

The result from Table VIII shows that the overall project-based extension was rated as high ($x=3.57$, $std= 0.776$) with a slight variation from the responses. This means that project-based extension service is very necessary to ensure the provision of economic, relevant, effective, and efficient agricultural advice to increase the likelihood of achieving food security. The economy of project implementation is about giving a high-quality service, while effectiveness is about outputs. Efficiency is about both inputs and outputs while relevance relates to access and the people's satisfaction with public services. Again, the high rating of overall project-based extension denotes that, AEAs are well equipped with managerial and entrepreneurial skills that enable them to translate extension education into the achievement of project objectives. [26] advised that public managers should act as entrepreneurs by employing scarce resources in new ways to maximize productivity and effectiveness through the act of searching for more efficient and effective ways of managing and abandoning old policy programs and methods and rather be innovative, imaginative, and creative. Extension services provide an efficient and effective linkage among farmers, researchers, non-governmental organizations, and others to improve the relevance and impact of extension services in achieving food security.

TABLE VIII. SUMMARY OF AEAs' PERCEIVED LEVEL OF PROJECT-BASED EXTENSION DELIVERY SERVICES

Project-based extension delivery	Mean	Std. Dev.
Effectiveness	3.81	0.76
Relevance	3.58	0.77
Economy	3.50	0.91
Efficiency	3.41	1.04
Overall Rating	3.57	0.78

Source: Field Survey (2021)

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)

C. AEAs Perceived Level of Food Availability, Accessibility, Utilization, and Stability during the covid-19 pandemic

Table IX shows the AEAs' perceived level of food availability during the COVID-19 pandemic in the Upper East region. The results show that the availability of food was moderate ($x=3.32$, $std=0.878$) with little variation in responses. This implies that, during the COVID-19 period, food was conveniently obtainable within the region due to domestic food produced and harvested by farmers as directed by education from the project-based extension delivery. The World Food Program defines food availability as the amount of food present in a country or area through all forms of domestic production, imports, food stocks, and food aid. The availability of harvested food ($x=3.58$, $std=0.927$) indicates that the project-based extension delivery aided the availability of food by encouraging the production, harvesting, distribution, exchange, and marketing of food. [2] reported that food availability relates to the supply of food through production, distribution, exchange, storage, processing, transport, packaging, and marketing of food to ensure food security at the regional and country level.

TABLE IX. AEAs PERCEIVED LEVEL OF FOOD AVAILABILITY

Component of Availability of food	Mean	Std. Dev.
Harvested food	3.58	0.93
Marketed food	3.36	1.05
Produced food	3.34	0.93
Distributed food	3.31	1.08
Exchanged food	3.00	1.27
Overall Rating of Food Availability	3.32	0.88

Source: Field Survey (2021)

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 X depicts AEAs' perceptions of food accessibility in Ghana's Upper East Region during the COVID-19 period. There is a modest amount of food accessibility ($x=3.29$, $std=0.984$) and minimal diversity in responses. This exemplifies how project-based extension delivery can boost food production, efficient transportation, and the capacity to distribute food to another area of the region that was experiencing a food shortage. According to the World Food Program, food accessibility is accomplished when adequate food is continuously available to all people in a nation or area. Furthermore, the modest incidence of food availability from processors, restaurants, marketplaces, farms, and food delivery services indicates that food was physically available in the area even during COVID-19. The capacity to receive various food

from farmers, processors, and markets in their quality and quantity is graded as part of the access dimension of food security at the individual, family, community, national, regional, and global levels [27]. Even in rural regions, most people, particularly the poor, depend on market systems for food, needed products, services, and the sale of their production.

TABLE X. AEAs' PERCEIVED LEVEL OF FOOD ACCESSIBILITY

Components of Accessibility to Food	Mean	Std. Dev.
Appropriate food from processors	3.34	1.12
Diverse food from restaurants	3.34	1.09
Quality food from markets	3.31	1.11
Sufficient food from farms	3.23	1.12
Adequate food from food delivery services	3.23	1.15
Overall Rating of Accessibility	3.29	0.98

Source: Field Survey (2021). Scale: 1.00-1.44=very low, 1.45-2.44= low, 2.45-3.44=moderate, 3.45- 4.44=high, 4.45-5.00=very high

Table XI depicts AEAs' perceptions of food used during the pandemic in Ghana's Upper East Region. Food use was modest ($x=3.25$, $std=0.983$) with little heterogeneity in responses, according to the findings. The outcome demonstrates how project-based extension delivery reinforced food safety and wholesomeness practices to meet nutritional needs. World Food Summit defines food usage to be "Safe and nutritious food that satisfies dietary demands". Food utilization is the appropriate biological use of food, which necessitates a diet rich in energy and necessary nutrients, as well as access to clean water and basic sanitation [2]. The contribution of project-based extension delivery in supporting the practice of food safety to satisfy nutritional requirements is shown using proportions of bought, stored, prepared, allocated, and processed food. Resilient project policies, according to [28], might impact food processing, buying, storage, and use. Extension plays a role in food usage, food processing, and suitable storage technologies through disseminating information about food storage and processing procedures at the household and regional levels.

TABLE XI. AEAs PERCEIVED LEVEL OF FOOD UTILIZATION

Components of Utilization of Food	Mean	Std. Dev.
Purchased food	3.37	0.87
Stored food	3.33	1.29
Prepared food	3.31	1.08
Allocated food	3.15	1.14
Processed food	3.11	1.20
Overall Rating of Food Utilization	3.25	0.98

Source: Field Survey (2021)

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 XII shows the findings of AEAs' perceptions of food stability during the pandemic in Ghana's Upper East Region. Food stability had a good rating ($x=3.60$, $std=0.900$) from the responders, with little variance. This indicates that the necessity of decreasing the risk of unfavourable impacts on food availability, access, and use was highlighted in the project-based extension delivery. The stability dimension addresses the

fact that people's food security situations change over time, but all people are food secure at all times to achieve national food security objectives. Agricultural extension's knowledge transfer role has gained traction in the face of increased climatic variability because it educates farmers on adaptation and mitigation strategies to overcome the risk of crop and animal production failure, which threatens household food security. Pandemic outbreaks, price volatility, resource fluctuation, and climate change all received high rankings, indicating that AEAs had to use project-based extension delivery as a tool to ensure food stability in terms of availability, access, and utilization for food security to exist during the COVID-19. Climate change and disease outbreaks, according to [29], may alter food pricing and supply chain variables, causing resource variations. Extension services can assist farmers in making decisions about viable livestock and crop diversification options to cope [30]. Even though adverse weather and political instability can affect individual food security, the common trend in studying food stability at the macro level is to focus on sudden shocks (e.g., pandemics, economic and climatic crises) or cyclical events (e.g., seasonal food insecurity) that threaten availability and access.

TABLE XII. AEAs PERCEIVED LEVEL OF FOOD STABILITY

Stability of food	Mean	Std. Dev.
Epidemic outbreaks	3.70	1.17
Price volatility	3.68	1.01
Resource fluctuation	3.61	1.07
Climate change	3.58	1.07
Income variability	3.43	1.20
Overall Rating of Food Stability	3.60	0.90

Source: Field Survey (2021)

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 XIII displays the findings of AEAs' perceptions of overall food security in Ghana's Upper East region during the pandemic. Food security was rated moderate during the COVID-19 period ($x = 3.36$, $std = 0.847$), with some variation among respondents. This indicates that by boosting food availability, access, usage, and stability, the project-based extension delivery was able to lower the risk of food insecurity. Food availability, access, use, and stability are all concepts used to describe food security (WFP, 2009). In recent years, agricultural growth has outpaced non-agricultural growth, expanding food security (accessibility, utilization, availability, and stability) by an average annual rate of 5.5 %, compared to 5.2 % for the non-agricultural sector of the African economy [32]. As exemplified by AEAs in Ghana's Upper East region using project-based extension delivery during the COVID-19 pandemic period, to be food secure, a population, household, or individual must be guaranteed the availability of food, access to adequate food, and proper utilization of that food consistently [31].

TABLE XIII. SUMMARY OF FOOD SECURITY INDICATORS

Food Security	Mean	Std. Dev.
Stability	3.60	0.90
Availability	3.32	0.87
Accessibility	3.30	0.98
Utilization	3.25	0.98
Overall Rating of Food Stability	3.60	0.90

Source: Field Survey (2021)

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)

D. Relationships between the Project-Based Extension Delivery Services and Food Security

The relationship between knowledge management capacity and organizational performance was investigated using a Pearson product-moment correlation matrix. Table XIV shows the Pearson product-moment correlation matrix for the research variables. The correlation coefficient (r) was graded as follows: 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. At the 0.01 alpha level, there was a positive and highly significant link between food security and efficiency ($r=.797$), relevance ($r=.780$), and economy ($r=.841$). This means that the Upper East region's food security depends on the efficient, appropriate, and cost-effective execution of project-based extension. According to [33], the effective function of the extension is crucial in promoting innovative approaches and raising awareness among agricultural communities so that guidelines may be implemented to suit a country's dietary demands. Because extensionists are properly educated in terms of local organizational development and utilize accurate and reliable yardsticks to assess the economy, efficiency, and effectiveness of various programs, they may help impoverished farmers acquire access to money via savings or loans.

At the 0.01 alpha level, there was a positive and significant association between food security and the effectiveness of AEAs ($r=0.554$). The findings indicate that project-based extension has a favourable impact on food production and food security. This is in accordance with the findings of [36], who found that successful extension was the key driving factor for credit availability and the use of technologies that promote food security in Ethiopia. According to [34], access to extension services improves farmer efficacy, resulting in increased food security and poverty reduction in Bangladesh aquaculture.

However, at the 0.05 alpha level, there was a positive and modest significant association between food security and sex ($r=.184$). This means that the gender of AEAs has an impact on their effectiveness, efficiency, economy, and relevance in delivering project-based extension methodologies that aim to influence food security in the region, albeit at a lower rate. This finding supports [35] assertion that men and women perceive reality differently, have different expectations placed on them, and that while women are classified as emotional, men are classified as rational. Women are more inclined to share information since they are more sensitive to instrumental ties and face typical vocational obstacles.

Nonetheless, at the 0.01 alpha level, there was a negative yet strong significant association between food security and AEA Extension Zones ($r = -0.257$). This means that the geographic zones where AEAs conduct project-based extension services (mostly rural regions) have an inverse connection with regional food security. This is because, even though most AEAs' operational zones were found in rural areas, AEAs prefer to live in urban and peri-urban areas and commute to work with farmers in rural areas, rather than staying in rural communities with farmers daily to ensure that extension services are readily available. However, [36] explained that, because rural farmers require knowledge of a variety of aspects of rural income to improve their livelihoods and reduce their vulnerability to poverty, extension services must be made available to them regardless of their geographic location. A study, [36] found that three-quarters of the world's poor live in rural areas and rely on agriculture for a living. As a result, AEAs are more likely to benefit farmers if they stay in the farming communities with the farmers rather than AEAs preferring to live in urban and peri-urban areas and commute to work with farmers in rural areas.

TABLE XIV. CORRELATION MATRIX OF PROJECT-BASED EXTENSION DELIVERY SERVICES AND FOOD SECURITY

Independent variables	Correlation Coefficient(r)	Significance (p)	Type of Correlation	Strength of Relationship
Sex (X_1)	0.18*	0.03	Point Biserial	Low
Extension Zone (X_5)	-0.26**	0.00	Biserial	Low
Effectiveness (X_7)	0.55**	0.00	Pearson	Substantial
Efficiency (X_8)	0.79**	0.00	Pearson	Very High
Relevance (X_9)	0.78**	0.00	Pearson	Very High
Economy (X_{10})	0.84**	0.00	Pearson	Very High

Source: Field Survey (2021)

E. Collinearity Diagnostic Test

From Table XV, the collinearity diagnostic test showed that there was no significant collinearity among the independent variables. Thus, the study result was not affected by multicollinearity which may bias the prediction (Table XV). According to [37], the Variance Inflation Factor (VIF) shows how much the variance of the coefficient estimate is inflated by multicollinearity. VIF close to 10 is a cause for worry yet tolerance closer to 1 indicates no collinearity while a tolerance value of zero (0) indicates a severe multicollinearity problem.

TABLE XV. COLLINEARITY DIAGNOSTIC TEST

Independent Variable	Tolerance	VIF	Durbin Watson
Sex (X_1)	0.67	1.49	
Age (X_2)	0.39	2.59	1.5
Years of experience (X_3)	0.51	1.97	
Level of education (X_4)	0.69	1.43	
Extension Zone (X_5)	0.79	1.27	
Place of Work (X_6)	0.64	1.56	
Effectiveness (X_7)	0.44	2.26	
Efficiency (X_8)	0.25	3.93	
Relevance (X_9)	0.11	9.13	
Economy (X_{10})	0.14	7.11	

Source: Field Survey (2021)

F. Ordinary Least Square Regression of Project-Based Extension Delivery Services on Food Security

The ordinary least square regression of the level of project-based extension delivery practices of AEAs is shown in Table XVI (appendix 1). The data was analyzed using the Ordinary Least Square (OLS) regression in a stepwise manner. Three factors (Economy, Efficiency, and Age) jointly explained 79% of the effect of project-based extension delivery on the level of food security in the Upper East region.

The first overall best predictor, Economy (X_{10}), explained 71% of the effect of project-based extension delivery on the level of food security in the Upper East region, according to Table XVI (appendix 1). This means that AEAs were able to practice and teach farmers how to follow proper economic practices in their spending decisions by avoiding unnecessary costs and spending only what is necessary or justifiable to achieve food security. According to [38], the concept of economy is especially important in government projects because the government's resources are limited and must be spent wisely. This means that when financial decisions are made and government fiscal policies are established, great care should be taken not to harm the interests of one group or to unfairly advance the interests of another group at the expense of others.

During the COVID-19 pandemic, efficiency (X_8) accounted for (6%) of the influence of project-based extension delivery on food security. This means that AEAs were able to teach farmers how to apply agricultural principles to make the region food secure by understanding the relationship between the goods and services produced (outputs) and the resources used to produce them (inputs). [41] found that AEAs were able to deliver information to the agriculture industry (input) by using available online tools, increase farmers' output efficiently, and achieve organizational goals. The effective use of resources in farming has a direct impact on a region's food security.

Furthermore, during the COVID-19 pandemic, the age (X_2) of AEAs contributed (2.0%) to the impact of project-based extension delivery on food security. This trend could be significant for the concept of knowledge usage, as it is expected that young AEAs will be interested in using high technology for knowledge acquisition, conversion, application, and protection. This assumption contradicts [39] who found significant differences in knowledge acquisition but not knowledge application between age groups. [40] discovered a more definite relationship between age and knowledge sharing and extension with the elderly preferring to transmit knowledge to the younger generation rather than learning from the younger generation.

G. Perceived Level of Food Security in the Upper-East of Ghana between Males and Females AEAs

Table XVII (appendix 1) shows the results of an independent t-test comparing male and female AEAs' perceptions of food security in the Upper East region. The means and stds demonstrate that male AEAs ($x=3.27$,

std=0.790) rated regional food security as moderately high, whereas female AEAs (\bar{x} =3.62, std=0.944) rated regional food security as high, with smaller variances in their replies. The assumption of homogeneity of variances was also evaluated and found to be true using Levene's F test, with F (8.80) being significant (0.004), indicating that equal variance was not assumed. At 0.05 alpha levels, the independent t-test (Table

XVII) reveals a significant ($p=0.043$) difference in perceptions of male and female AEAs on the perceived level of food security in the region. This means that, although both male and female AEAs believe the region's food security is strong, female AEAs are somewhat happier than their male counterparts.

TABLE XVI. ORDINARY LEAST SQUARE REGRESSION OF PROJECT PROJECT-BASED EXTENSION DELIVERY SERVICES ON FOOD SECURITY

Predictors	Step of Entry	Beta(β) (standardized)	R ²	Adj R ²	AdjR ² Change	S.E.E.	F. Change	F. Sig*
X_{10}	1	0.49	0.71	0.71	0.71	0.46	342.58	0.00
X_8	2	0.34	0.76	0.77	0.06	0.42	32.43	0.00
X_2	3	-0.13	0.78	0.79	0.02	0.40	13.11	0.00

Source: Field Survey (2021)

TABLE XVII. INDEPENDENT T-TEST SHOWING DIFFERENCES IN THE PERCEIVED LEVEL OF FOOD SECURITY IN THE UPPER EAST BETWEEN MALES AND FEMALES AEAS.

							95% Confidence Interval		Levene's Test for Equality of Variances	
Sex	n	Mean	Std. Dev.	Mean difference	T	Sig	Lower Bound	Upper Bound	F	Sig.
Male	104	3.27	0.79	-0.35	-2.1	0.04	-0.68	-0.01	8.80	0.00
Female	40	3.62	0.94							

Source: Field Survey (2021). Scale: Equal variances not assumed

TABLE XVIII. ONE-WAY ANALYSES OF VARIANCE (ANOVA)

						95% Conf. Inter. for Mean		Levene's Statistic	
Zones	n	Mean	Std. Dev.	F	Sig	Lower Bound	Upper Bound	Levene's Statistic	Sig
Central	48	3.81	0.82	13.1	0.00	3.57	4.05	2.49	0.08
Eastern	48	3.01	0.75			2.79	3.22		
Western	48	3.28	0.79			3.05	3.51		

Source: Field Survey (2021)

This implies that a person's sexual orientation has an impact on how they perceive food security. Sex has an impact on work group processes due to a phenomenon known as "from information to decision-making perspective variance." This logic is based on the idea that people with different demographic characteristics have different points of view. Thus, hiring women in a business is not expected to be merely a show of improving gender equality within the workforce but assuring a sustainable future since it entails reduced demand for high birth rates and net migration [42]. Because gender equality is seen as critical in the fight against malnutrition and hunger, organizations should function as a knowledge-integrating institution, including the knowledge of many different persons and groups in the process of generating products and services [43]. It's worth mentioning that procedures and technology aren't enough to propel a business forward; the human force (personnel) plays a critical role in its success. As a result, [44] urged managers to create circumstances that would increase workforce diversity in their firms since a more diverse workforce is better for an organization's internal and external competitiveness.

H. Perceived Effect of Project-Based Extension Delivery Services on Food Security in the Three (3) Operational Zones of the Upper-East Region of Ghana

A one-way analysis of variance (ANOVA) was used

to test whether there were any statistically significant differences in the mean of AEAs' perceived impact of project-based extension delivery on food security in the three (3) operational zones in the study areas. At 0.05 alpha, there were substantially significant ($p=0.000$) variations in the averages of AEAs' perceived impact of project-based extension delivery on the level of food security in the three (3) operational zones of the research area, as shown in Table XVIII (appendix 1). The assumption of homogeneity of variances was also examined and found to be true using Levene's statistics (2.498) as not significant (0.086), indicating that equal variance was assumed.

This suggests that across the three (3) AEA operating zones in the research area, there are variances in levels of AEAs' perceived influence of project-based extension delivery on the degree of food security. According to [45], AEAs' performance (effectiveness, efficiency, relevance, and economy) may differ in terms of diagnosing a situation, planning, organizing, producing and disseminating appropriate information due to differences in knowledge of social networks, mass media, groups, mass, and interpersonal communications. According to [46], rural agricultural development may improve if the government plans, coordinates, and budgets for AEAs' readiness for the digital era, willingness to educate farmers in the new normal era, and motivation to consult with stakeholders in extension delivery services. The outcome demonstrates the critical role that AEAs' managerial abilities play in resource

management, allocation, and utilization in achieving established objectives. Outcomes-focused management ensures that government entities offer services that are effectively aligned with the public interest and make optimal use of resources. Instead of asking whether resources were spent efficiently, effectively, and economically, [4] asked whether the people whose needs are being served and who are at the endpoint of public institutions' activities have received a fair share from the services being rendered by public bodies.

I. Post-hoc Analyses of Differences in AEAs'

Perceived Effect of Project-Based Extension Delivery on Food Security in the Three (3) Operational Zones in the Upper-East Region of Ghana

A post hoc comparison analysis was undertaken to discover where the unique discrepancies were across the three AEA operating zones in the studied region (Table XIX). Since the assumption of homogeneity of variances was examined and met using Levene's statistics (2.498) which also indicated no significant significance (0.086), an equal variance was assumed. Therefore, LSD was utilized for the post-hoc comparison analysis. Central and Eastern zones ($x=3.29$, $SEE=0.984$), Central and Western zones ($x=3.29$, $SEE=0.984$), but not Eastern and Western zones ($x=3.29$, $SEE=0.984$) showed significant differences. Because the extension zones are at various phases of development significant variances were noticed. Although agriculture remains the most important economic activity in Ghana's Upper East region, the central AEA's operational zone is more urbanized. In contrast to the region's eastern and western operating zones, which are more rural and comprised of more peasant farmers, it has more advanced mechanized farmers owing to the availability of markets for their products. Furthermore, the bigger the fraction of the rural population whose primary source of income is subsistence farming (without access to pro-poor technology and markets), the higher the frequency of malnutrition. Hunger and child malnutrition are more prevalent in rural regions than in metropolitan ones. Rural farmers require knowledge of several aspects of rural incomes to improve their livelihoods and reduce their vulnerability to poverty. Therefore, advances in agricultural production directed at small-scale farmers should assist the rural impoverished peasant farmer first rather than constantly targeting the advanced mechanized farmer [36].

TABLE XIX. POST-HOCK ANALYSES

Zones (A)	Zones(B)	Mean Diff. (A-B)	Std. Err	Sig	95% Confidence Interval for Mean	
					Upper Bound	Lower Bound
Central	Eastern	0.80	0.16	0.00	0.49	1.12
	Western	0.53	0.16	0.00	0.22	0.85
Eastern	Central	-0.80	0.16	0.00	1.12	-0.49
	Western	-0.27	0.16	0.09	-0.59	0.04
Western	Central	-0.53	0.16	0.00	-0.85	-0.22
	Eastern	0.27	0.16	0.09	-0.04	0.59

Source: Field Survey (2021)

IV. CONCLUSION

The study reveals that AEAs, predominantly male, demonstrate a high level of effectiveness in delivering extension services, particularly in inspiring farmers and improving service delivery timelines. The paper stresses the importance of AEAs' role in enhancing food security, as evidenced by their positive influence on the economic aspects of project-based extension delivery. In the context of the COVID-19 pandemic, the research emphasizes the crucial role of AEAs in maintaining food availability, accessibility, utilization, and stability. The positive correlation between food security and efficiency, relevance, and economy further emphasizes the pivotal role of AEAs in promoting innovative approaches and raising awareness among agricultural communities. Additionally, the findings emphasize the need for AEAs to focus on rural areas to ensure broader access to extension services. The study identifies the age of AEAs as a factor influencing their contribution to food security, highlighting the importance of considering generational dynamics in extension services. The study also highlights regional disparities in AEAs' perceptions, emphasizing the need for tailored extension strategies based on the unique characteristics of each operational zone. This research significantly advances our understanding of the intricacies of project-based extension delivery services and their impact on food security. While acknowledging the positive contributions of AEAs, the study identifies areas for improvement, including addressing gender imbalances, refining extension strategies based on regional disparities, and incorporating innovative approaches to enhance the overall effectiveness of agricultural extension services.

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