Agricultural extension services and household welfare: evidence from Ghana socioeconomic panel survey

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Abstract

While agriculture is integral to the development plans of many developing countries, the sector and those who work in it face several challenges. Agricultural extension and advisory service (AEAS) is prescribed as essential to addressing some of these challenges, but the evidence base is thin, especially in Ghana, where most existing studies are based on cross-sectional, regional, and small-sample analyses. The absence of rigorous and generalizable analyses limits evidence-informed advocacy, planning, and decision-making on AEAS. To address this evidence gap, we analyze the effects of AEAS on poverty, assets, per capita consumption, and dietary diversity based on three waves of the nationally representative Ghana Socioeconomic Panel Survey. We find that AEAS is associated with a 28.3% increase in household and farm assets, 20% increase in value of per capita food consumption, and a 4.2% increase in household dietary diversity. Disaggregated by provider type, households receiving extension service advice from farmer-based organizations show the highest increase across these welfare outcomes. Despite these positive effects, the uptake of AEAS is generally low and especially from service providers other than government sources. Furthermore, those who received AEAS show null or negative results for poverty. We recommend that the government further strengthen the extension service system, specifically by encouraging uptake of extension services from government and non-government providers.

Keywords: Agricultural education, Food security, Inverse probability weighted, Matching methods, Panel survey, Sub-Saharan Africa

JEL Classification: Q16, Q12, O13, I32, D12, O55

1. Introduction

The agricultural sector employs an estimated 26% of the global workforce and contributes about 4% to the world's Gross Domestic Product [1]. The relevance of the sector is more pronounced in developing countries, where about 3.4 billion rural people depend on agriculture and the food system for their livelihoods, and about 70% of total employment in some of these countries is agriculture-based [2,3,4]. In Ghana, 40% of the employed population works in agriculture [1]. Despite the sector's integral role in the global and local economy, agriculture workers struggle with food insecurity and low production [5]. Yields are suboptimal [6,7] as key crops such as maize, rice, yam, cassava, and plantain yield less than half of their potential due to constraints such as primitive farming techniques, reliance on rain-fed production, limited adoption of modern agricultural equipment, constrained access to financial services, and inadequate agricultural services [6,7,8,9].

Agricultural Extension and Advisory Services (AEAS) hold the potential to mitigate the highlighted agricultural challenges [7,10,11,12], as shown by scholars who investigate this vis-à-vis the productivity and well-being impact on farmers. However, the scholarship on the subject is inconclusive, given differing findings on AEAS's role in farmers' agricultural productivity and well-being [13]. Some strands of the literature [13,14,15,16,17,18] suggest a significant correlation between agricultural extension services and increase in farmers' knowledge and adoption of new technologies. Beyond technology adoption, others empirically accentuate the positive effect that receiving extension services has on farmers' productivity, yield, income, poverty reduction, dietary diversity, and food security [19,20,21,22,23,24,25,26]. Asante et al. [27] found that farmers who embraced agricultural services in the Brong Ahafo region of Ghana experienced an increase in maize yields, gross revenue, and per capita food consumption. Anang et al. [8] showed a similar positive effect of AEAS on farmers' income in the northern region. Among farmers who received AEAS delivered by NGOs and religious-based organizations, Attipoe et al. [28] and Danso-Abbeam et al. [7], respectively, showed a positive impact on productivity and income.

In contrast, several studies have documented null or even adverse effects of AEAS on farmers' outcomes. In Argentina, Maffioli et al. [29] find that publicly subsidized extension services negatively affected farm yields, attributing the decline to short-run adjustment costs. In Nigeria, Aremu and Reynolds [19] report a significant reduction in household assets among recipients of AEAS focused on animal care and marketing, while their study also identifies a positive association between AEAS exposure and food insecurity, suggesting unintended welfare consequences. Beyond economic impacts, Kalogiannidis and Syndoukas [30] raise environmental concerns, noting that some extension programs promote intensive farming practices contributing to negative externalities. Ragasa and Mazunda [25] find AEAS access in Malawi improves food security and farm productivity, while Sebaggala and Matovu [31] find no significant relationship between AEAS and crop yields. These mixed findings underscore the heterogeneity of AEAS effects across settings, delivery modalities, and outcome dimensions.

The conflicting interplay between AEAS and farmers' welfare necessitates more research, especially studies that are more representative and that delve into specific subjects of agricultural advice to offer useful policy recommendations. Previous studies have been regionally skewed toward the North [32,7,9,8,33], with very few studies in the South [16,27,28]. This geographical skewness is primarily due to data constraints, rendering such studies not generalizable. Many of these studies are also based on cross-sectional data. These two challenges affect the internal and external validity of previous research, with significant implications for extension policymaking in Ghana.

To that end, our study empirically investigates the impact of AEAS on household welfare in Ghana and makes three contributions. Firstly, to the best of our knowledge, this study is the first to leverage a novel, nationally representative, micro-level panel dataset to assess the impact of AEAS on household welfare in Ghana. Secondly, beyond the binary variable of extension access, we disaggregate the source of advice into farmer-based, input dealers, and government-based extension services. We hypothesize that these channels differ not only in modes of delivery but also in underlying incentives, information quality, and reach. Lastly, our focal outcomes of interest are more comprehensive than previous studies, comprising poverty, household assets, per capita food consumption, and dietary diversity.

Our analysis offers evidence in support of a positive and statistically significant relationship between AEAS and assets, household food consumption, and household dietary diversity,

including advice received via farmer-based organizations and government personnel. We recommend that the government strengthen the extension advisory system, by paying attention to non-state providers to increase the benefits of AEAS to farmers in Ghana.

2. Agricultural extension and advisory service in Ghana

AEAS in Ghana dates to the early twentieth century and has undergone several reforms. Before independence in 1957, missionaries and foreign-based companies delivered AEAS to enhance productivity and boost export production [34]. After independence, the system was criticized for prioritizing export crops at the expense of food crops, prompting a shift in 1978 to a Ministry-based general extension approach focused on food crop production [35,36]. In the early 1990s, this approach was again criticized for being top-down, focusing on 'progressive farmers' while neglecting smallholders and women [37,38]. In 1992, the Unified Extension System (UES) was implemented alongside the Training and Visit (T&V) program, but the combined approach was criticized for being rigid and lacking linkage with research [34,39]. In 1996, the Government of Ghana implemented a decentralization reform, transferring activities to the Metropolitan, Municipal, and District Assemblies (MMDAs) [39,40,41]. Today, the Ghanaian AEAS system is pluralistic, consisting of the Government through the Directorate of Agricultural Extension Services (DAES), NGOs, private institutions, religious-based organizations, and cooperative institutions [41]. However, the effectiveness of these programs is often limited by inadequate training and support beyond the initial AEAS [7], and inequitable implementation has been linked to widening income and gender disparities [32,20].

3. Methods

3.1 Data

This study uses three waves of panel data from the Ghana Socioeconomic Panel Survey, collected by the Institute of Statistical, Social and Economic Research (ISSER) at Legon in partnership with the Economic Growth Center at Yale University and the Global Poverty Research Lab at Northwestern University. The first wave was collected between 2009 and 2010, the second between 2010 and 2013, and the third between 2018 and 2019. The dataset is designed to be nationally representative and contains information on household demographic and health characteristics, farm characteristics, assets, consumption, and expenditure. Each wave consists of about 5,000 households.

For this analysis, we obtain information on access to extension service, geographic characteristics (region), household head characteristics (age, gender, education), household durable goods, cooking fuel, wall materials, and consumption expenditure. Gender is coded as 0 if male and 1 if female. The agricultural extension service variable is measured as a dichotomous variable where 0 indicates no access and 1 indicates access. Extension service is first measured as having access to the service, regardless of source (general). Then, we differentiate between sources, i.e., services delivered by farmer-based organizations, input dealers, or government extension providers. After data cleaning, we had a balanced panel of 12,015 observations with 4,005 households in each wave.

3.2 Outcome variables

We test the effects of access to agricultural extension on four outcomes: poverty, household assets, per capita food consumption, and dietary diversity. The first outcome, poverty, is based on the Innovation for Poverty Action-supported Poverty Probability Index (PPI) score. The PPI is a set of ten questions about household characteristics and assets assigned weights that sum up to a continuous index ranging from 0 to 100. While the score can be interpreted probabilistically, it is not inherently binary; rather, it provides a gradient of poverty risk, with 0 representing the highest likelihood of poverty and 100 the lowest [42]. For Ghana, the ten questions cover the region, household size, purchase of chicken eggs, purchase of raw or corned beef, outer wall construction materials, cooking fuel, and ownership of gas stove, refrigerator, fan, and television.

For assets, we measure the monetary value of the sum of household and farm assets reported by households. For food consumption, we construct it as the monetary value of the sum of food produced and purchased by households less the amount given out as gifts in the last 30 days, divided by the number of household members. Given limited dataset information, we could not exclude food produced for sale from total household production, nor did we use a price deflator to account for spatial and temporal variation. Dietary diversity is based on the household dietary diversity score (HDDS), computed using 12 food classes (cereals, roots, pulses, oil, fruits, vegetables, meat, eggs, milk, beverages, sugar, alcohol) consumed in the last 30 days [43,44].

3.3 Empirical strategy

To assess the association between access to extension services and household welfare outcomes, we employ a combination of propensity score matching (PSM), nearest neighbor estimation (NNE), and inverse probability weighted regression adjustment (IPWRA). These methods improve comparability between households that did and did not receive extension advice by conditioning on observable characteristics. The panel structure enables us to control for time-invariant household-level heterogeneity. While these methods reduce bias from observable differences, the results should be interpreted as associations rather than causal estimates, as unobserved confounding may persist.

We adopt the potential outcomes framework following Abadie and Imbens [45], where treatment is binary. Let W represent the treatment variable (extension access), X the covariates, and Y the outcome variable. We define W=1 if farmers received extension services and W=0 if not. The average treatment effect (ATE) is:

$$ATE = E[Y_1 - Y_0] \quad (1)$$

The average treatment effect for the treated (ATT) is:

$$ATT = E[Y_1 - Y_0 \mid W = 1] \quad (2)$$

From Eq. (2), we can only observe $E[Y_1|W=1]$; $E[Y_0|W=1]$ is missing. According to Wossen et al. [18], a simple comparison of outcomes for those who received extension services and those who did not introduces self-selection bias of magnitude $ATT + E[Y_0|W=1] - E[Y_0|W=0]$.

A notable assumption of treatment effects is the overlap assumption: each farmer has a positive probability of receiving each treatment level, and potential outcomes and treatment statuses of all other farmers are independent. PSM is not agnostic to model specification and produces biased results if mis-specified [46]. Two solutions exist: nearest neighbor estimation, which uses a bias correction term and does not require a functional form, but relies on global distance measures and can be sensitive to outliers; and IPWRA, which has a doubly robust property, allowing the model

to be consistent and efficient even if one of the models (treatment or outcome) is mis-specified [46].

Empirically, Imbens and Wooldridge [47] show that IPWRA estimates selection to treatment, predicts treatments for all observations, assigns the inverse probability of treatment for treated individuals and the inverse probability of not being treated for control individuals, and re-estimates the outcome model with the new weights. From a logistic regression as the propensity score:

$$e(X_i) = P(W_i = 1 \mid X_i) \quad (3)$$

The inverse probability weight for each observation is:

$$\omega_i = W_i/e(X_i) + (1 - W_i)/(1 - e(X_i)) \quad (4)$$

We fit the outcome for the treated and untreated using covariates X:

$$\hat{Y}_1(X_i) = E[Y_i \mid W_i = 1, X_i] = g_1(X_i) \quad (5)$$

$$\hat{Y}_0(X_i) = E[Y_i \mid W_i = 0, X_i] = g_0(X_i) \quad (6)$$

Combining the inverse probability weights and the regression adjustment yields:

$$\hat{\mu_1} = (1/N)\, \Sigma\, [W_i Y_i/e(X_i) - ((W_i - e(X_i))/e(X_i))\, g_1(X_i)] \quad (7)$$

$$\hat{\mu_0} = (1/N)\, \Sigma\, [(1 - W_i)Y_i/(1 - e(X_i)) - ((1 - W_i) - (1 - e(X_i)))/(1 - e(X_i))\, g_0(X_i)] \quad (8)$$

The difference between Eqs. (7) and (8) yields the ATE of the IPWRA. Formally:

$$ATE\_IPWRA = \hat{\mu_1} - \hat{\mu_0} \quad (9)$$

$$ATT\_IPWRA = \hat{\mu_1} - \hat{\mu_0} \mid W = 1 \quad (10)$$

4. Results

4.1 Descriptive statistics

The panel dataset contains 12,015 household-wave observations across three survey rounds. Some variables are not observed in every wave for all households due to item nonresponse, survey skip patterns, or variable-specific attrition. To address this, we used the missRanger algorithm in R to impute missing values. Missingness was generally low: apart from rural and HDDS, which had 3.89 percent missing values, all other variables had less than 1 percent missingness.

Table 1 presents averages of the outcome variables and continuous covariates. The mean PPI score is 45.5. The average value for log of assets is 6.7 (812.41 Ghanaian cedis), while the mean for log of per capita food consumption is 4.2 (66.69 cedis). The average HDDS is 5.2. Both asset and food consumption measures are log-transformed to reduce the influence of extreme values. The average age of household heads is 50 years, and the average household size is 4.

Table 1. Summary statistics of panel sample

	count	mean	sd	min	max
Log of Assets (HH+Farm)	12,015	6.6827	1.6855	0	13.6204
Poverty Probability Index Score	12,015	45.507	22.3129	0	100
Log of Per capita Food Consumption	12,015	4.1780	1.0184	−1.6095	9.1317

Household Dietary Diversity Score	12,015	5.2091	2.8419	1	11
Household head age	12,015	50.716	16.1161	18	111
Size of the household	12,015	3.7359	2.4092	1	20

Across all three waves, access to extension remained limited. In each round, approximately 11 percent of households reported receiving any form of extension support, with the remaining 89 percent reporting no access. When disaggregated by provider type, government agencies accounted for the largest share of extension access, with 7 to 9 percent of households reporting government-provided services in each wave. Access through input suppliers was more limited, at 2 to 3 percent of households per wave. Farmer-based organizations were the least accessed provider, with under 2 percent of households reporting any engagement.

In terms of household characteristics, 79 percent of households receiving extension support were male-headed, compared to 60 percent among those with no access. Rural households comprised 85 percent of those who accessed extension services. Education attainment levels also differed: 45 percent of households who accessed extension had no formal education, compared to 40 percent among those who did not. Ownership of phones and media (radio and television) was relatively balanced across groups, with about 70 percent of households reporting ownership of at least one communication device.

4.2 Propensity matching quality

Before presenting the main results, we assess the quality of the matching process. The distribution of predicted propensity scores for treated (extension service access) and untreated households overlaps substantially, with most observations concentrated between 0.1 and 0.3. Both treated and untreated households are well represented across the score range, indicating that the reweighting and matching procedures are built on a strong foundation of overlap.

The unweighted sample exhibited notable imbalances in key covariates such as household size, gender of the household head, and rural/urban location. After applying inverse probability weights, balance improved markedly across all covariates: standardized differences fell near zero and variance ratios approached 1. Table 2 shows matching quality metrics. The lower Pseudo R^2 after matching indicates a reduction in the ability of the covariates to predict treatment assignment. The likelihood ratio chi-squared shows a significant reduction from the unmatched sample (664.92) to the matched sample (8.28). The reduction in mean and median bias also points to improved balance after matching.

Table 2. Propensity score matching quality metrics

Sample	Unmatched	Matched
Pseudo R^2	0.074	0.002
Likelihood ratio chi^2	664.92	8.28
$p > chi^2$	0.00	0.996
Mean bias	14.7	1.7
Median bias	9.2	1.3
Percentage of Variance	100	50

4.3 Effect of receiving extension on welfare outcomes

Table 3 presents the average treatment effects on the treated (ATT) of access to any form of agricultural extension services on four key welfare outcomes. Across all three estimation strategies, we observe consistently positive and statistically significant effects on household assets, food consumption, and dietary diversity. The log of household assets increases by 0.184 (or 20.2%) under PSM, 0.137 (or 14.7%) under NNE, and 0.249 (28.3%) under IPWRA, each significant at the one percent level. Food consumption effects range from 0.122 (13%) to 0.202 (22.4%). Dietary diversity gains range from 0.279 to 0.505 points. For the PPI, results vary more substantially: PSM and NNE indicate significant reductions in poverty likelihood (−0.201 and −0.881 respectively), while the IPWRA estimate (−0.227) is not statistically significant.

Table 3. ATT of general extension services on outcome variables

	PSM	NNE	IPWRA
Log of Assets	0.184*** [0.062]	0.137*** [0.051]	0.249*** [0.035]
Log of Per capita Food Consumption	0.202*** [0.037]	0.122*** [0.028]	0.190*** [0.019]
Household Dietary Diversity Score	0.492*** [0.102]	0.279*** [0.070]	0.505*** [0.053]
Poverty Probability Index Score	−0.201** [0.632]	−0.881** [0.406]	−0.227 [0.305]
N	12,015	12,015	12,015
Controls	Yes	Yes	Yes

*Robust standard errors in brackets. *, **, *** indicate significance at 10, 5, and 1 percent levels, respectively.*

4.4 Effect of extension access from different sources

Effect on household assets

Table 4 indicates that receiving agricultural extension advice is positively associated with household asset accumulation. This relationship is statistically significant for services from farmer-based organizations and government providers, particularly in the PSM and IPWRA models. Access to advice from farmer-based organizations is associated with an increase in assets of approximately 28.9–31.8%. Government-provided services show a similarly strong association, with increases ranging from 13.7 to 29.7%. Advice from input dealers does not produce a statistically significant effect on household assets.

Effect on food consumption

Across provider types and model specifications, there is a generally strong positive relationship between extension advice access and per capita food consumption. For households accessing services from farmer-based organizations, there is an increase of 18.3% to 29.4%. For input dealers, the increase is between 10.1 and 19.5% (NNE model insignificant). For government providers, the increase is between 12 and 35% (Table 4).

Effect on dietary diversity

Receiving extension service shows a strong positive relationship with household dietary diversity across providers. For farmer-based organizations, there is an increase of 0.60 to 0.87 points. For input dealers, the increase is between 0.32 and 0.52 points (NNE insignificant). Government-provided extension corresponds to an increase of 0.30 to 0.75 points.

Effect on poverty probability

Results are mixed across estimation methods. For farmer-based organizations, none of the models yield statistically significant estimates, and the direction of the effect varies. For input dealer-sourced extension services, the IPWRA model shows a statistically significant negative association with PPI score (−1.703), suggesting lower poverty probability among households accessing input dealer advice, while other models report null effects. Government-provided extension exhibits a statistically significant negative association in the NNE specification (−1.154), though this is not robust across methods. These findings imply that the estimated association between extension access and poverty is sensitive to both the type of provider and the choice of estimation method.

Table 4. ATT of extension service by provider type on welfare outcomes

Outcome / Provider	PSM	NNE	IPWRA
Log of Assets			
Farmer-based org.	0.254** [0.122]	0.187 [0.137]	0.276*** [0.090]
Input dealers	0.128 [0.110]	0.033 [0.099]	0.084 [0.073]
Government	0.295*** [0.064]	0.128** [0.058]	0.260*** [0.041]
Log of Per capita Food Consumption			
Farmer-based org.	0.287*** [0.094]	0.168** [0.085]	0.258*** [0.059]
Input dealers	0.178** [0.071]	0.068 [0.056]	0.096** [0.042]
Government	0.300*** [0.039]	0.114*** [0.032]	0.221*** [0.022]
Household Dietary Diversity Score			
Farmer-based org.	0.871*** [0.282]	0.601*** [0.196]	0.684*** [0.147]
Input dealers	0.515*** [0.195]	0.067 [0.150]	0.316*** [0.115]
Government	0.746*** [0.107]	0.297*** [0.081]	0.591*** [0.060]
Poverty Probability Index Score			
Farmer-based org.	1.887 [1.702]	0.853 [1.204]	−0.145 [0.823]
Input dealers	−0.310 [1.127]	−0.990 [0.775]	−1.703*** [0.571]
Government	0.838 [0.732]	−1.154** [0.482]	0.181 [0.355]

*Standard errors in brackets. *, **, *** indicate significance at 10, 5, and 1 percent levels. N = 12,015 with controls in all specifications.*

5. Discussion and policy implications

Our study makes important contributions to the literature on the benefits of receiving AEAS in Ghana. We provide a nationally representative panel analysis that addresses external and internal validity concerns of previous cross-sectional and limited size studies. Among our three treatment effects models, IPWRA stands out for its doubly robust property, yielding consistently lower standard errors.

Studies on AEAS [19,48] suggest that the pathway from receiving extension service ends with more income and consumption, reduced poverty, and improved food security and value of household assets. The IPWRA model shows an increase of 28.3% in assets, 20.9% in the value of

per capita food consumption, and 4.2% in dietary diversity score among households that received AEAS. Disaggregating by source, receiving extension services from farmer-based organizations is associated with an increase of 31.8% in assets, 29.4% in per capita food consumption, and 5.7% in dietary diversity score. For input dealers, we found null result on assets, 10.1% increase in food consumption, and 2.6% increase in dietary diversity. Government extension providers show 30% increase in assets, 24.7% in food consumption, and 4.9% in HDDS. However, we found null or statistically significant negative results with poverty probability across all extension variables and model specifications. Our findings extend existing evidence for productivity and income [8,27,7] by showing AEAS improves assets and food security.

The disaggregated results provide new insights. Previous studies have generally treated AEAS as undifferentiated [8,27] or focused narrowly on NGO/religious-based services [28,7]. AEAS delivered by farmer-based organizations shows the largest positive effects across all welfare outcomes, followed by government and input dealer services. This aligns with literature highlighting the role of farmer-based organizations such as cooperatives and producer associations in improving smallholder outcomes in Ghana, including enhanced access to extension services, input markets, credit, and technical information, and enabling collective action and bargaining power [49,50,51,52,53]. Asante et al. [50] report that membership increases access to farm machinery and market information, while Moore et al. [52] emphasize participatory approaches in facilitating technology adoption. Buadi et al. [51] find farmers perceive extension services delivered by these organizations as particularly effective due to timeliness and contextual relevance.

While concerns remain about the economic sustainability of farmer-based organizations and barriers to participation for resource-constrained farmers [52,49], the evidence suggests these groups serve as important institutional channels for scaling extension services. Our findings support policies that strengthen the long-term viability and inclusiveness of such organizations, especially in a context currently dominated by government-based extension. One option would be for the government to train lead farmers or private input sellers to provide basic agricultural advisory services in areas underserved by public agents. Digital channels for extension, including mobile messaging, radio, and television, offer further opportunities to expand reach. The growing potential of artificial intelligence also presents a promising avenue for delivering personalized and context-sensitive advice to remote farming communities.

The null or negative result of AEAS on poverty reduction could be because receiving advice on good practice or new technology alone is not enough to lift people out of poverty, especially when many farmers in the country are subsistent and grow for their own consumption [54]. Future studies may explore this relationship using income as an outcome measure. Other studies argue there is potential in crop and labor diversification to adapt to shocks and improve food security, income, and poverty among smallholder and most vulnerable households [55,56,57,58]. If extension services are to contribute to poverty reduction, policies may need to focus on encouraging diversification, particularly among poor and smallholder households, and policies that support market access, infrastructure development, and value chain integration can complement extension services.

Our study has limitations. Even though there are differences in growing conditions, decision making, and poverty status between the north and south of Ghana, which often influence the use of agricultural extension services [54], our analysis did not discuss these geographical dynamics. Whether farmers in certain regions, with certain land sizes, growing certain crops, or in certain

wealth quartiles have better access to and effects from extension service remains an open question. We also acknowledge the potential role of input subsidies in shaping both access to extension services and household welfare. Disentangling these confounding influences remains an important task for future research.

6. Conclusion

While governments in developing countries rely on the potential of agriculture to drive development, this sector faces challenges that limit such potential [27,7]. The AEAS system that could potentially help farmers is poorly serviced, mired in inconclusive evidence, or advocated for with non-generalizable evidence. Our study provides evidence in support of the role of AEAS in livelihood improvements in Ghana, particularly for assets, food consumption, and dietary diversity. Given currently low levels of overall adoption and domination by government sources, policies should focus on supporting alternative sources such as those by farmer-based organizations and input dealers.

Full disaggregated regression tables (covariate balance, full model estimations for general and source-disaggregated extension services) and the propensity score density figure are available in the published journal version [59].

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