

Assessing the impact of agricultural technology diffusion projects: the case of the Cowpea Out-scaling Project (COSP) in Ghana

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Abstract

Agricultural technology diffusion projects are promoted as pathways to enhancing the productivity and welfare of smallholder farmers. Yet, there remain questions about the extent to which these projects impact the productivity, profitability, and welfare of farmers. This study assesses the impact of the Cowpea Out-scaling Project (COSP), an agricultural technology diffusion project sponsored by the USAID, on cowpea productivity, cowpea revenue, and household cowpea consumption using data from 596 cowpea-producing households and applying the Inverse Probability Weighted Regression Adjustment (IPWRA) estimator to account for selection bias. The results reveal a nuanced picture of the project's effectiveness. Participation in COSP had a statistically significant positive impact on cowpea yield, resulting in an average increase of 95.36kg/ha among beneficiary households. We also found a marginally significant positive effect of the project on cowpea revenue of the beneficiary households (GHS 328). However, our analysis did not find any statistically significant impact on household cowpea consumption. These results suggest that, while agricultural technology diffusion projects can be effective in increasing farm-level outcomes, increased farm-level production does not translate automatically into improved nutritional outcomes or household income. Future agricultural development interventions should adopt an integrated, nutrition-sensitive approach that includes explicit post-harvest management strategies to ensure that yield gains lead to improvements in both economic well-being and household nutrition.

Key Words: Ghana, project evaluation, cowpea, technology-diffusion, smallholder farmers, welfare

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1.0 Introduction

Agriculture remains the backbone of the economies of many developing countries, serving as the primary source of livelihood for a significant portion of the population and an important driver of national development, especially in sub-Saharan Africa (SSA) (Kebede, 2020). Despite its significance, the sector faces persistent challenges, including low productivity, vulnerability to climate change, pest and disease outbreaks, and limited access to critical resources and modern technologies (Ahenkan et al., 2021; Mensah et al., 2021). Addressing these bottlenecks is crucial for achieving food security, reducing poverty, and fostering sustainable rural development, which aligns with some of the Sustainable Development Goals (SDGs), notably SDG 1 (No Poverty) and SDG 2 (Zero Hunger).

In Ghana, agriculture contributes significantly to the Gross Domestic Product (GDP), employing about 33% of the workforce, with smallholder farmers forming the majority of the agricultural workforce (SRID (Statistics Research and Information Directorate), 2022). Among the many crops cultivated in Ghana, cowpea (*Vigna unguiculata* L. Walp) stands out as an important leguminous crop. It is a dual-purpose crop, providing both nutritious grain for human consumption and valuable fodder for livestock, thus playing a critical role in household food and nutrition security, and contributing to soil fertility through nitrogen fixation (Abdou, 2022; Boukar et al., 2018; Tripathi et al., 2024). Cowpea is especially significant in Northern Ghana, where it serves as both a cash and food crop and a key source of protein for many rural households, especially during lean seasons. It is a food security crop in Northern Ghana, bridging the hunger gap between planting and harvest seasons of the main staple cereals (Wahaga, 2019).

Notwithstanding the socio-economic and environmental importance of cowpea, its production falls significantly below its potential. Farmers often obtain low yields due to reliance on traditional farming practices, limited access to improved seeds, high incidence of pests (e.g., Maruca pod borer, aphids), and inadequate knowledge of modern agronomic techniques (Crop Trust, n.d.; Egbadzor et al., 2013; Horn et al., 2022; Horn & Shimelis, 2020; Karikari et al., 2023). These challenges result in a substantial "yield gap"—the difference between potential and actual farm yields—perpetuating poverty and food insecurity among cowpea farmers.

Recognizing these challenges and the immense potential of cowpea, various interventions have been initiated by governmental and non-governmental organizations to bridge the yield gap. One such initiative was the Cowpea Out-scaling Project (COSP), implemented from 2015 to 2017 in selected districts in the Northern, Upper East and Upper West Regions of Ghana. The COSP was a USAID-sponsored project, implemented by the International Institute for Tropical Agriculture (IITA) through the CSIR-Savanna Agricultural Research Institute (CSIR-SARI) in Ghana. The project had three main objectives, the achievement of which various activities were designed. The first objective of COSP was to strengthen the seed system in Ghana thereby improving access to high-quality locally available seeds of improved cowpea varieties by smallholder farmers. The second objective of COSP was to improve agricultural practices and pest management of improved cowpea varieties. This was to reduce the prevalence of destructive cowpea pests on cowpea fields, thereby increasing cowpea yields. The last but not least objective of the project was to improve the storage of cowpea as well as increase home consumption of cowpea. Improved storage was to enable small-scale farmers to store their cowpea and sell it later at higher prices. Increased home consumption of cowpea was to take the nutritional advantage of the crop to increase the nutritional levels of the resource-poor farmers, thereby reducing malnutrition, especially among women and children.

Agricultural technology dissemination projects, such as COSP, are a cornerstone of efforts to enhance food security, improve rural livelihoods, and foster sustainable development, especially in developing countries such as Ghana. These projects aim to transfer innovations – ranging from improved crop varieties, better agronomic practices, pest and disease management techniques, to post-harvest technologies – often from research institutions to farmers. While such project interventions are often lauded for their intentions, a critical assessment of their actual impact on beneficiary farmers and communities is indispensable for evidence-based policymaking and effective resource allocation (Al Daccache et al., 2024; Danso-Abbeam et al., 2018; GezahegnWordofa & Sassi, 2017; Sibhatu et al., 2022). Despite the significant investment and effort in agricultural technology dissemination, there remains questions about the extent to which these efforts translate into measurable impact on productivity, profitability, and welfare of farmers, thus, there remains a persistent need for rigorous empirical studies that quantify the socio-economic and productive impacts of such initiatives at the farm household level (Danso-Abbeam et al., 2018; GezahegnWordofa & Sassi, 2017; Hossain et al., 2024; Mulugeta & Heshmati, 2023; Sibhatu et al., 2022). While many studies have examined the adoption and impact of agricultural technologies in isolation, relatively few have focused on evaluating the outcomes of structured out-scaling projects like COSP. Specifically, there is a dearth of comprehensive impact evaluations that precisely attribute changes in farmer outcomes to specific technology diffusion projects like COSP in the Ghanaian context.

Our study, therefore, seeks to fill this knowledge gap by assessing the impact of the Cowpea Out-scaling Project (COSP) on key socio-economic and production outcomes among beneficiary farmers in the project districts of Ghana. By utilizing a robust analytical method, this study compares the performance of beneficiary households with a comparable group of non-beneficiary households, thereby providing empirical evidence on the project's effectiveness. Our study findings will contribute significantly to the existing body of knowledge on agricultural technology diffusion and impact evaluation in sub-Saharan Africa. Again, the findings will offer valuable insights for policymakers, development practitioners, and research institutions in developing countries in general, and in Ghana, in particular, informing the design and implementation of future agricultural development interventions intended at boosting crop production and improving farmer welfare.

The remainder of this article is organized as follows: Section 2 outlines the methodology employed in the study, detailing the study areas, the sampling procedure, and the empirical estimation procedures. Section 3 presents the results of the impact assessment. Section 4 discusses the implications of the findings. Finally, Section 5 provides conclusions and policy recommendations.

2. Cowpea production in Ghana

In Ghana, cowpea (*Vigna unguiculata*) is predominantly cultivated in the dry savanna zones, which are characterized by a unimodal rainfall pattern occurring between May and September, with annual rainfall ranging between 500–1200 mm (Atiah et al., 2021). Northern Ghana alone accounts for approximately 85% of the country's total cowpea grain production (Herniter et al., 2019). Despite this dominance, domestic production remains insufficient to meet national demand, necessitating the importation of substantial quantities to bridge the supply deficit (Quaye et al., 2011). The cowpea seed system is a critical component of food security and income generation for smallholder farmers in Ghana (Karikari et al., 2023). It is characterized by the coexistence of both formal and informal channels. The formal sector comprises government agencies, research institutions, and commercial seed companies that are mandated to produce, certify, and distribute improved cowpea seeds (Martey et al., 2025). However, access to improved seeds through this channel remains limited, particularly for

smallholder farmers, due to high costs, weak distribution networks, and inadequate institutional capacity (Martey et al., 2025). In contrast, the informal sector—dominated by local seed producers, farmer-to-farmer exchanges, and community-based markets—plays a more significant role in meeting farmers' seed needs. Although this system is more accessible and culturally embedded, the quality of seeds supplied is often inconsistent and generally lower (Lyon & Afikorah-Danquah, 1998). The cowpea seed system faces several challenges, including limited access to improved and early maturing varieties, weak institutional structures for seed quality regulation, high incidence of pests and diseases, and agronomic constraints such as poor seed germination, low pod filling, small grain size, and low yields. Additional barriers include high input costs, difficulty in harvesting, and consumer-preferred traits such as grain color and size not always being met (Martey et al., 2025). Collectively, these challenges perpetuate the prevalence of low-quality seeds in local markets, thereby constraining productivity growth and undermining the potential of cowpea as a food security and income-generating crop for smallholders in Ghana (Karikari et al., 2023).

3. Methodology

3.1 Study Area

Northern Ghana is currently made up of five administrative regions (Northern, North-East, Savanna, Upper East, and Upper West regions). It shares boundaries with Burkina Faso to the north, Togo to the east, and Ivory Coast to the West. It covers two main agroecology's; the guinea savannah and the Sudan savannah agroecological zones. Northern Ghana experiences tropical savanna climate with a single rainy season from May to October and a dry season dominated by the harmattan winds from November to February. Annual rainfall ranges between 800 mm and 1,200 mm, with the highest precipitation occurring in August. The vegetation consists of Guinea savanna, interspersed with baobab and shea trees, providing fertile grounds for agricultural activities. Figure 1 shows the administrative map of the study area.

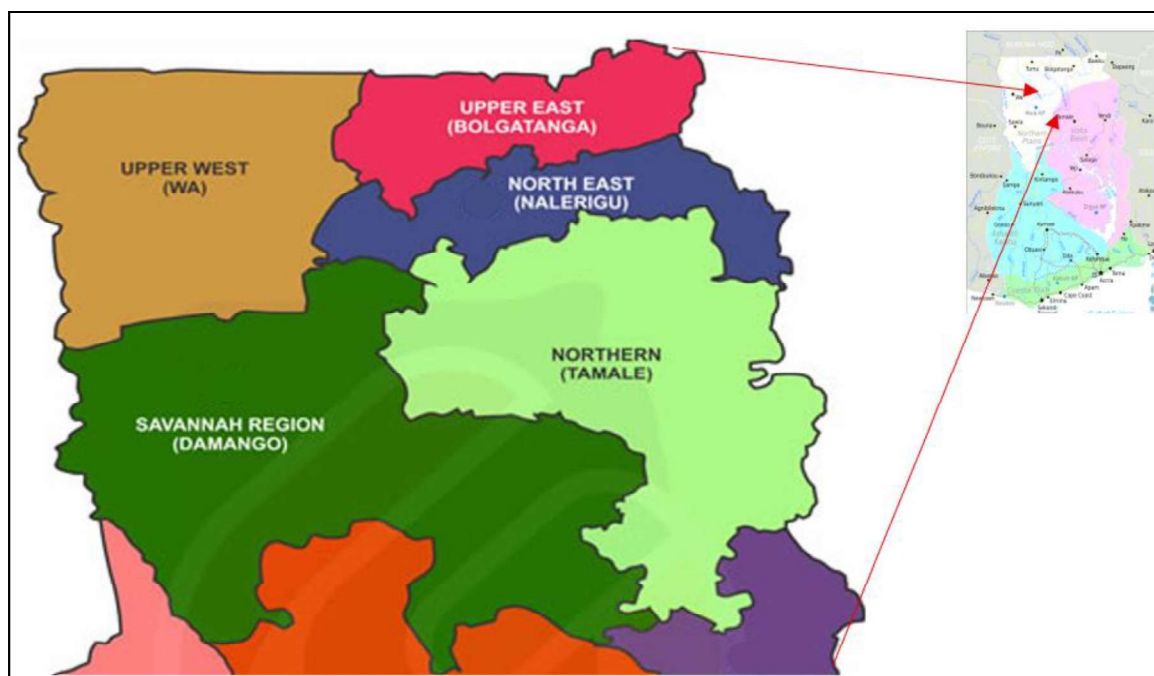


Figure 1. Administrative map of the study area

3.2 Data and Sampling

Data for this study was collected in the 2018/2019 cropping season from a sample of 596 cowpea producers from the Northern, Upper East and Upper West regions of Ghana. The data was collected using structured questionnaires administered through informal interviews. A multistage sampling procedure was used. In the first stage, a random sampling of 20 from 38 COSP intervention districts in the three regions was done. The second stage involved the random selection of COSP intervention communities in the selected districts. After the random selection of COSP intervention communities, two control communities were purposively selected from each region to add to the sample of communities. Control communities were at least 20km away from the nearest COSP intervention community. This was to assess the spill-over effect of the project's activities. The final stage of the sampling procedure involved the selection of respondents for the interviews. Each project community had

several beneficiaries. A random draw of beneficiaries from each community was done proportional to the size of the beneficiary group. Four non-beneficiary cowpea producers were also selected in each of the sampled project intervention communities. Eight cowpea farmers were then randomly selected from each of the control communities. In all, the total sample size drawn was 596 cowpea producers, comprising of both COSP participants and non-participants. Data collected captured information of respondents' demographic characteristics, farm characteristics, cowpea production, institutional factors, consumption, as well as on welfare indicators.

3.3 The COSP Theory of Change Framework

The conceptual framework guiding the implementation of COSP was the Theory of Change and the Impact Pathway framework. The framework explained how the project was expected to lead to its intended outcomes and impacts, mapping out the causal pathways and identifying assumptions underlying the expected change. The Theory of Change is presented in Figure 3.

The supply and consumption of cowpea grain and cowpea-based products in Ghana are limited due to low productivity resulting from poor access to quality seeds and other inputs, high rates of post-harvest losses, and a lack of knowledge about the nutritious value of cowpea. Thus, cowpea productivity can be increased significantly by using good-quality seeds of improved varieties in addition to the adoption of good agricultural practices, such as integrated pest management (IPM) technologies. The low consumption of cowpea grains and other cowpea-based products is caused by the inadequate knowledge of the benefits of consuming cowpea by households.

Although improved cowpea varieties have been developed and released by research institutions, they are not widely adopted by farmers due to a limited awareness of these varieties and an ineffective seed system (Martey et al., 2020, 2022). Therefore, to cause any improvement in the supply and consumption of cowpea and/or cowpea based-products, efforts should focus on: i) strengthening the local seed system, mainly through assisting community-based organizations (CBOs) to overcome existing bottlenecks and produce quality-declared seeds that are accessible and affordable to farmers, ii) increasing awareness and creating the demand for good quality-seed of the improved cowpea varieties, iii) reducing associated post-harvest losses through awareness campaigns, trainings, and promoting the adoption of Purdue Improved Cowpea Storage (PICS) bags and other post-harvest handling and storage technologies, iv) raising awareness and training of households on the nutritional benefit of consuming cowpea and/or cowpea based products and, 5) linking seed producers, grain producers and processors to inputs and outputs markets along the cowpea value chain through well established and well-functioning Innovation Platforms (IP).

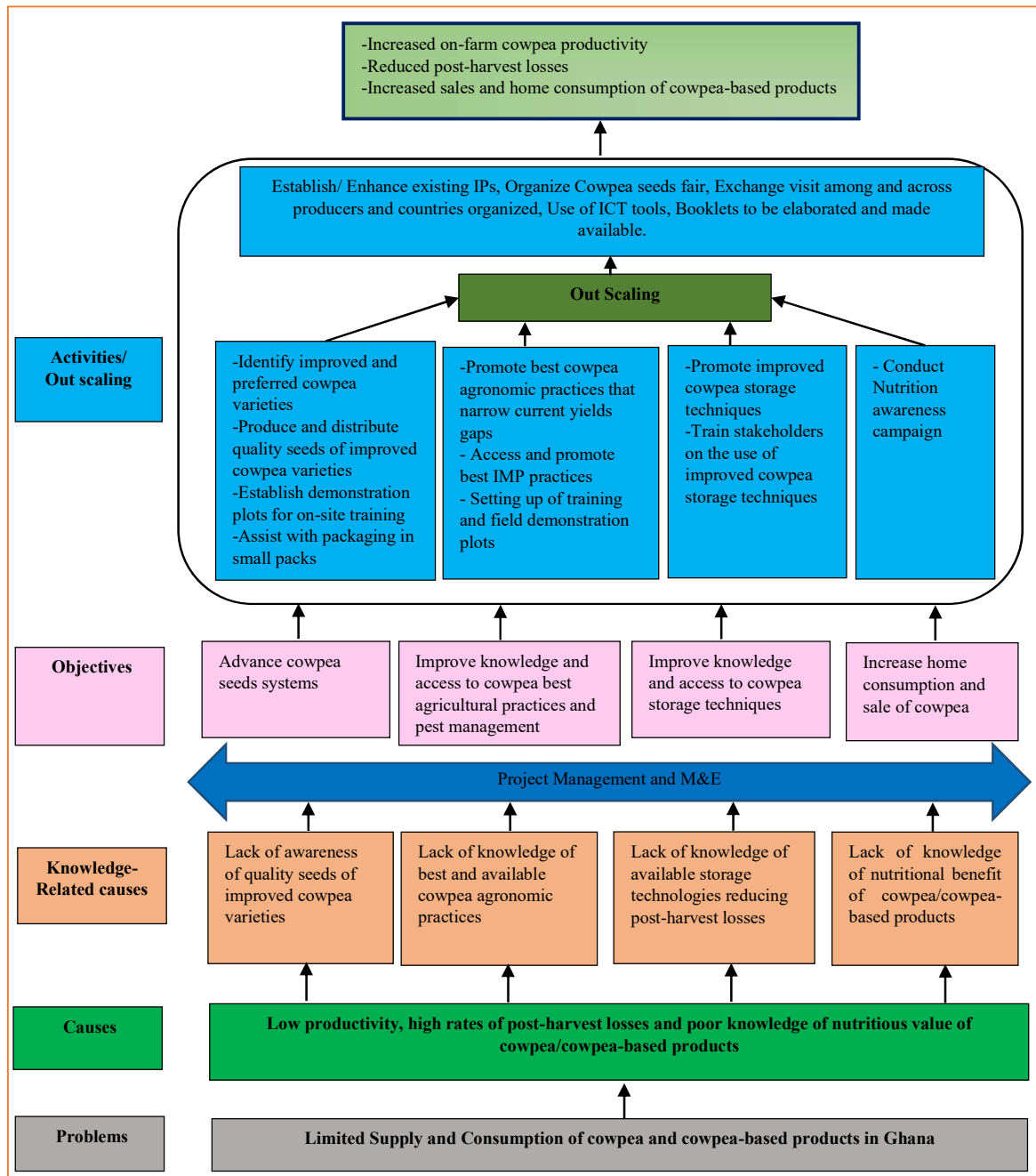


Figure 2. Conceptual model of Cowpea Out-scaling Project (COSP) on farmers welfare

3.4 Empirical Strategy

3.4.1 The Rubin Causal Model/Potential Outcome Framework

To assess the impact of the Cowpea Out-scaling Project (COSP) on beneficiary farmers, we adopt the Rubin Causal Model (RCM), also known as the Potential Outcomes Framework (Imbens & Rubin, 2015; Rubin, 1979). The RCM provides the theoretical framework for defining and estimating causal effects through the conceptualization of the outcomes that would be observed under different treatment conditions. In this framework, each individual has two potential outcomes, with and without the intervention (treatment).

Let $t_i = \{0,1\}$ represent a binary treatment (in this case, participation in COSP) such that $t = 1$ is the treatment status and $t = 0$ is the status without the treatment. Let also y_i be the outcome of interest resulting from the

treatment for an individual (e.g cowpea yield, cowpea revenue or cowpea consumption). Then, the individual has two potential outcomes as follows:

$$y_i = \begin{cases} y_{1_i} & \text{if } t_i = 1 \\ y_{0_i} & \text{if } t_i = 0 \end{cases} \quad (1)$$

y_{1_i} = Potential outcome if the individual participates in COSP

y_{0_i} = Potential outcome if the individual does not participate in COSP

The observed outcome y_i can be written in terms of the potential outcomes (y_{1_i}, y_{0_i}) as:

$$y_i = y_{0_i} + (y_{1_i} - y_{0_i})t_i \quad (2)$$

where $(y_{1_i} - y_{0_i})$ is the causal effect of participation in COSP for the individual.

The fundamental challenge of causal inference is that we do not observe both potential outcomes for an individual at the same time. For any given individual, we only observe one of these potential outcomes – either y_{1_i} if he or she participated in COSP, or y_{0_i} if he or she did not participate in COSP. To determine the effect of treatment, we have to compare the expected outcome of the treatment group to the expected outcome of the untreated group.

3.4.2 Average Treatment Effect

Since individual causal effects cannot be observed, we have to estimate the average causal effects across a population or subgroup. Our aim in this study is to estimate the Average Treatment Effect on the Treated (ATET), which measures the average impact of COSP participation specifically for those farmers who actually participated in the project. To do so, we have to compare the expected outcome of the treatment group to the expected outcome of the untreated group as in equation (3).

$$ATE = E(y_i | t_i = 1) - E(y_i | t_i = 0) \quad (3)$$

Equation (3) can be rewritten as:

$$E(y_i | t_i = 1) - E(y_i | t_i = 0) = \{E(y_{1_i} | t_i = 1) - E(y_{0_i} | t_i = 1)\} + \{E(y_{0_i} | t_i = 1) - E(y_{0_i} | t_i = 0)\} \quad (4)$$

The first part of equation (4) is the average treatment effect on the treated (ATET), and the second part is the selection bias. Selection bias is the difference between the outcome of individuals who were treated and the outcome of individuals who were not treated that was not due to treatment.

3.4.3 Inverse Probability Weighted Regression Adjustment

Given that farmers' participation in COSP was not random, the participants and non-participants may be systematically different in ways that influenced both their decision to participate and their observed outcomes (selection bias). Empirical economic research aims to overcome selection bias and therefore find the true causal effect of the treatment variable (Angrist & Pischke, 2009).

To account for the selection bias, most approaches to estimating average treatment effects fall into one of three categories: ignorability or unconfoundedness of treatment conditional on a set of covariates, selection into treatment based on unobservable factors and selection into treatment being a discontinuous function of an observed forcing variable (Wooldridge, 2010). We employed the Inverse Probability Weighted Regression Adjustment estimator (IPWRA) to estimate the effects of participating in COSP on cowpea yield, cowpea revenue and quantity of cowpea consumed.

IPWRA is an estimation procedure based on the ignorability of treatment conditions on a set of covariates. It combines regression adjustment (RA) and inverse probability weights (IPW) estimation procedures. The combination of RA and IPW provides robustness against misspecification of the parametric models, as it only requires either the treatment or the outcome equation to be correctly specified (Wooldridge, 2010). Apart from the ignorability of treatment assumption, this estimator also relies on the overlap and independent-identically-

distributed (iid) sampling assumptions (Cameron & Trivedi, 2005). The estimation in this paper was done following the procedure outlined by Wooldridge (2010) and implemented by Boansi et al. (2024).

$$\min_{\alpha_1, \beta_1} \sum_{i=1}^N (y_i - \alpha_1 - \beta_1 x_i) / p(x_i, \hat{\gamma}) \quad \text{if } t_i = 1 \quad (5)$$

$$\min_{\alpha_0, \beta_0} \sum_{i=1}^N (y_i - \alpha_0 - \beta_0 x_i) / (1 - p(x_i, \hat{\gamma})) \quad \text{if } t_i = 0 \quad (6)$$

$$ATE_{ipwra} = N^{-1} \sum_{i=1}^N [(\hat{\alpha}_1 - \hat{\beta}_1 x_i) - (\hat{\alpha}_0 - \hat{\beta}_0 x_i)] \quad (7)$$

where $(\hat{\alpha}_1, \hat{\beta}_1)$ and $(\hat{\alpha}_0, \hat{\beta}_0)$ are the estimated inverse probability weighted parameters for $t = 1$ and $t = 0$ respectively and $p(x_i, \hat{\gamma})$ is the estimated propensity scores.

4.0 Results and Discussion

4.1 Characteristics of Cowpea Producers by Beneficiary Status

The descriptive characteristics of the sampled cowpea farmers by participation status are presented in Table 1. On the whole there is very minimal variation in the characteristics of COSP beneficiaries and non-beneficiaries. About 76% of the farmers in the sample were males, further highlighting the dominance of males in the agriculture in the three northern regions. The average age of the sampled farmers was 44 years with about 21 years of farming experience. However, cowpea production was relatively new to both beneficiaries and non-beneficiaries of COSP with an average cowpea production experience of eight years. In terms of formal education, majority of the cowpea farmers (63.8%) have had formal education. Average household size of the respondents was about nine persons across beneficiaries and non-beneficiaries.

In terms of land area put under cowpea cultivation, COSP beneficiaries cultivated an average area of 0.8 hectares (2 acres) while non-beneficiaries cultivated about 0.68 hectares (1.7 acres). Cowpea yield of COSP beneficiaries was about 518 kg/ha compared to about 436 kg/ha of non-beneficiaries. Average quantity of cowpea consumed by COSP beneficiary households was about 104 kg against 91kg by non-beneficiary households. COSP beneficiaries made an average revenue of GHC 958 while non-beneficiaries' average revenue from cowpea sales was GHC 558.

Table 1: Characteristics of Cowpea Producers by Beneficiary Status

Variables	Beneficiaries	Non-Beneficiaries	Mean diff	Total sample
Sex (male)%	75.4	76.33	-	75.84
Age (years)	43	41	1.86	42
Farming experience (years)	21.3	19.6	1.71	20.5
Cowpea growing experience (years)	8.8	7.6	1.20	8.2
Formal education %	66.45	60.78	-	63.76
Household size (number)	9.0	8.0	0.81	8.8
Area under cowpea(ha)	0.80	0.68	0.12	0.74
Output of cowpea (kg)	393.18	271.46	121.72**	335.38
Quantity of cowpea consumed	103.69	90.82	12.86**	97.57
Yield (kg/ha)	517.73	435.86	81.87**	478.86
Revenue from cowpea (GHC)	958.14	557.86	400.28***	768.07

Source: Field Survey

4.2 Impact of COSP

This section presents the impact parameters of the outcome variables.

We first examine the outcome variables to determine if there are any differences in means between the beneficiaries and non-beneficiaries of COSP. Table 2 presents the mean differences of the outcome variables of interest. There are significant differences between beneficiaries and non-beneficiaries of COSP in all three outcome variables. However, at this point, conclusions cannot be drawn about the causal impact of participating in COSP yet, because the presented differences include selection biases. Hence, we need to use an econometric approach to partial out the differences due to selection bias to find the true causal impact of COSP participation.

Table 2: Mean Difference Test of Outcome Variables

Outcome	Beneficiaries	Non-Beneficiaries	Mean Difference
Yield (kg/ha)	517.73	435.86	81.87**
Cowpea Revenue (GHC)	958.14	557.86	400.28**
Cowpea Consumed (kg)	103.69	90.82	12.87**

** p<0.05

4.2.1 Impact of COSP on Cowpea Yield

The IPWRA analysis showed a statistically significant positive impact of COSP on cowpea yield as presented in Table 3. Specifically, participation in COSP resulted in a mean increase of 95.36 kg/ha for beneficiaries, which was statistically significant at 5%, indicating that the yield increase observed was not due to chance. This means that farmers who participated in COSP obtained a 95.36 kg/ha increase in yield compared to what they would have obtained without participating. The true effect of COSP participation can also be understood by comparing the potential outcome mean (POmean) of 422.37 kg/ha to the average yield of non-beneficiaries listed in Table 1. It suggests that, without participating in COSP, the beneficiaries would have obtained cowpea yields lower than the average of the non-beneficiaries. This finding aligns with the central hypothesis of COSP's Theory of Change (Fig 1), which posits that improved cowpea varieties and good agronomic practices, disseminated through demonstration plots and farmer trainings, would lead to an increase in yield. The yield increase can be attributed to several pathways within the Theory of Change. The use of improved cowpea, high-yielding varieties likely played a significant role in the yield increase. Furthermore, the use of best agronomic practices such as timely planting and integrated pest management (IPM), imparted through farmer training and practical demonstrations, would have contributed to the observed yield increase. The study finding corroborates with Lambongang et al. (2019), Awafo et al. (2024), and Prah et al. (2023) who found a positive impact of the Planting for Food and Jobs (PFJ) program on maize yield in Ghana. The findings are also consistent with that of Martey et al. (2021). These findings emphasize the importance of agricultural technology diffusion programmes and other agricultural extension initiatives in boosting farm-level productivity.

Table 3: IPWRA Estimates of Cowpea Yield (kg/ha)

	Coefficient	Robust std. Errors	Z
ATET	95.36	43.61	2.19**
POmean	422.37	38.73	10.91***
Other controls	Yes	Yes	Yes

** p<0.05, *** p<0.01

4.2.2 Impact of COSP on Cowpea Revenue

The impact of COSP on cowpea revenue was also estimated, and the results are presented in Table 4. The results indicate a positive, albeit marginally significant (10% level), impact of COSP on the cowpea revenue of beneficiary farmers. Specifically, participation in COSP increased the cowpea-derived revenue of beneficiaries by about GHS 328. Comparing the POmean of GHS 629.71 to the average revenue of non-beneficiaries of GHS 557.86 shows that COSP beneficiaries would still have had a higher revenue from cowpea even if they had not benefited from COSP. This could be due to other factors, such as better access to markets and market information, as well as the quality of grains. However, the magnitude of the impact of COSP on beneficiaries' revenue is observed by comparing the POmean of GHS 629.71 to the average cowpea revenue of beneficiaries (GHS 958.14) from Table 1. It means that the beneficiaries of COSP would have had an average revenue of about GHS 630 from cowpea if they had not participated in COSP.

This finding, although marginally significant, validates the economic impact pathway hypothesized in COSP's Theory of Change (Figure 1), which stated that an increase in cowpea yield through improved varieties and good agronomic practices, would translate into larger marketable surplus, which would then result in increased revenue for farmers. Our finding is consistent with that of Martey et al. (2021) who found participation in a

comprehensive agricultural training program to have a positive impact on cowpea income in northern Ghana. Similarly, Warinda et al. (2020) found that participation in on-farm regional projects has a positive impact on household crop income in East Africa. Participating in a government agricultural development support program improves the production and income of beneficiary smallholder farmers in South Africa (Mokgomo et al., 2022). Our finding contradicts that of Teka & Lee (2020) who found that participating in agricultural package programs did not have a statistically significant effect on income.

Table 4: IPWRA Estimates of Cowpea Revenue (GHS)

	Coefficient	Robust std. Errors	Z
ATET	328.42	173.21	1.9*
POmean	629.71	107.05	5.88***
Other controls	Yes	Yes	Yes

* p<0.1, *** p<0.01

4.2.3 Impact of COSP on Home Cowpea Consumption

The results of the IPWRA analysis of cowpea consumption are presented in Table 5. The analysis showed no statistically significant impact of participating in COSP on household cowpea consumption among the beneficiary farmers. Although a positive average increase of 3.69 kg in the consumption of cowpea was observed among beneficiary farmers, this effect was not statistically significant ($Z = 0.43$, $p > 0.1$), indicating that it could plausibly be due to chance.

Many different factors may contribute to this seemingly counterintuitive result, given the observed increase in cowpea yield. A primary explanation could be due to food preference. Cowpea is not a major staple crop in northern Ghana unlike maize and rice. Households usually keep the quantities that they need and dispose of the rest to raise income. Hence, an increase in yield may not necessarily increase home consumption. As noted by Gelli et al (2015), Increases in availability do not always lead to dietary change if cultural or taste preferences are not aligned. Another possible explanation for the yield increases not translating into increased consumption could be due to market-oriented production priorities. Farmers may prioritize selling cowpea for income instead of consuming it, especially if it has high market value. For instance, cowpea farmers in Nigeria often sell a large proportion of their harvest to meet immediate cash needs rather than retaining it for consumption (Dillon et al., 2015). Income generation is often a stronger motivation than food consumption in smallholder households' adoption of improved technologies (Fischer & Qaim, 2012). In contexts where rural households face diverse financial pressures, cash income from crop sales often takes precedence over increased own consumption of a specific commodity, especially if other food staples are available or preferred.

Additionally, factors like post-harvest losses could still reduce the amount of cowpea ultimately available for household consumption, despite higher production. For instance, postharvest losses of legumes in West Africa can be over 30% (Affognon et al., 2015) while Sugri et al. (2021) measured postharvest loss of 17.3% in cowpea in the Upper East region of Ghana. These losses significantly reduce the quantity available for consumption and marketable surplus.

Table 5: IPWRA Estimates of Cowpea Consumption (kg)

	Coefficient	Robust std. Errors	Z
ATET	3.69	8.55	0.43
POmean	100.01	7.80	12.82***
Other controls	Yes	Yes	Yes

*** p<0.01

5. Conclusion and Policy recommendation

This study aimed to evaluate the impact of COSP on three key outcome variables as outlined in the COSP's Theory of Change: cowpea yield, cowpea revenue, and home consumption of cowpea. We employed the IPWRA estimation procedure to account for the potential selection bias in participating in COSP. Our findings present a nuanced picture of agricultural technology diffusion interventions, revealing differential impacts across the outcome variables.

We found that COSP had a statistically significant (5% significance level) positive impact on cowpea yield among beneficiary households. This success suggests that the project was effective in transferring and promoting productivity-enhancing technologies and practices to its beneficiaries. The increase in cowpea yield shows that the project contributed towards improving the food security situation of the beneficiary households.

However, we found that the project's impact on cowpea revenue among the beneficiary households was only marginally significant positive (10% significance level), indicating that the yield increase did not wholly translate into revenue gains. Although at a low level of significance, the project contributed to reducing household poverty as envisaged in its Theory of Change.

Again, our analysis revealed that COSP did not have any statistically significant impact on the home consumption of cowpea among the beneficiary households, suggesting that the nutritional awareness campaign activities did not yield the desired outcome. It is possible that the project paid little attention to the activities aimed at achieving this objective.

Summarily, COSP had a strong impact on cowpea yield, a modest impact on cowpea revenue, and no impact on home consumption of cowpea among the beneficiary households. This disparity between increased production, modest revenue gains, and static consumption buttresses the point that increased production does not automatically translate into improved household welfare. Postharvest losses could account for the yield increase not significantly translating into revenue gains or consumption increases.

We recommend that future agricultural development interventions aiming to enhance both economic well-being and nutritional outcomes should adopt an integrated nutrition-sensitive approach. This entails designing interventions with explicit nutrition objectives in addition to the production targets. It also involves designing detailed postharvest management strategies to minimize postharvest losses. It is not just enough to include objectives on nutritional outcomes in agricultural development interventions; adequate budgetary allocation should be devoted to such objectives to achieve the desired outcome.

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