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# Farm Households' Welfare and Smallholder Rice Production in Northern Ghana: Does All-Year-Round Cultivation Make Any Difference?

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**Abstract**

The study relied on cross-sectional household level data collected from a randomly selected sample of 320 households in important rice growing areas in northern Ghana. The objective of the study was to assess the impact of all-year round rice production on the welfare of farm households employing Endogenous Switching Regression techniques. This approach enabled the estimation of the true welfare effect of all-year round rice production by dealing with selection problem on rice production and adoption decisions. Descriptive results showed a mean distance from the food expenditure poverty line of GHS46.17 with a significant difference between participants' (GHS16.03) and non-participants (GHS60.46). Also, with only 6.3% of all-year-round rice producers being poor in terms of food expenditure, as high as 23.6% seasonal rice producers are poor. Important factors contributing to higher household food consumption expenditure are farm size, non-farm work, contract farming and education whilst household size tends to reduce it. The study found that the observed per capita food expenditure (GHS 364.00) of farmers participating in all-year round rice production is much higher than their counterfactual per capita food expenditure of GHS 179.79, suggesting that engaging in all-year round rice production has a significant positive impact on household food consumption expenditure in northern Ghana where the bulk of the country's rice is produced. The finding implies that all-year round cultivation of rice has a potential role in improving rural household welfare as higher consumption expenditure translates into enhanced food security and lower poverty status of farm households. The study recommends the expansion in irrigation infrastructure in northern Ghana to encourage more farm families to adopt all-year round cultivation of rice.

**Keywords**: Northern Ghana; Endogenous Switching Regression; Food Consumption Expenditure; Food Security; Farm Household Welfare

## 1. Introduction

Agriculture's role is critical in the socio-economic lives of majority of people living in third world nations. Notwithstanding the rapid economic growth by many countries in the Sub-Sahara region in the recent past, the performance of the agricultural sector is still low, amidst high incidence of widespread poverty and food insecurity. Largely, vulnerability, low resilience to climatic change effects and poverty are pervasive in rural areas, resulting in poor nutritional status of the poor (Kitole, 2023). Agriculture is central in Africa's economic growth and economic development (FAO, IFAD and WFP, 2014) because it provides livelihood for over half of the continent's population. The sector constitutes the largest contributor to Gross Domestic Product (GDP), food security and poverty reduction to many countries on the continent (AGRA, 2018; Isaac, Clement and Darko, 2013). The sector is predominantly smallholder and rain-dependent (Vanlauwe, Coyne, Gockowski, Hauser, Huising, Masso, Nziguheba, Schut and Van Asten, 2014) and yet produces the largest proportion of the continent's food crops and contributing significantly to food security in sub-Saharan Africa (Dayamba, Ky-Dembele, Bayala, Dorward, Clarkson, Sanogo, Mamadou, Traoré, Diakité and Nenkam, 2018). Given that over 90% of Africa's smallholder agriculture system is rain-fed, Africa's economy and food security in particular stand to suffer severely from any anomaly in the climate (Rao, Ndegwa, Kizito and Oyoo, 2011).

Despite the avalanche of interventions to double agricultural productivity and incomes of small-scale food producers to end hunger and achieve food security and improved nutrition in developing countries (UNDP, 2017), the risks of widespread hunger and malnutrition appear to be rising in sub-Saharan African countries (AGRA, 2018; Kitole, 2010; Olanrewaju, Gbenga and Idris, 2019). Recent estimates indicate that between 2014-2018 while the growth in prevalence rate of undernourishment was 1.7% and 20.0% for Africa as a whole and sub-Saharan Africa respectively, no growth was observed for the rest of the world (FAO, ECA and AUC, 2020). This suggests that hunger and malnutrition remains a major development challenge in Africa, particularly in sub-Saharan Africa. While the exacerbating situation of food insecurity and malnourishment in developing countries can partly be attributed to poor and weakening market conditions (Ehui, 2020; Linderhof, Janssen and Achterbosch, 2019), stagnating agricultural productivity, environmental degradation, high rates of poverty and rapid population growth (AGRA, 2018; Kitole, 2010; Tefft, Jonasova, Adjao and Morgan, 2017), adverse weather conditions resulting from climate change appear to be a significant multiplier of the risks of food insecurity and malnutrition (Abdul Mumin and Abdulai, 2022; Abdulai, 2018).

With over 80% of Africa's poor living in rural areas and depending largely on agriculture for their livelihoods, the growth of the agricultural sector is clearly the key to rural poverty reduction and an important pathway to achieving the Sustainable Development Goal (SDG) of eliminating poverty by 2030 (UNDP, 2017). However, characterised by rain-fed conditions and minimal use of modern productivity-enhancing technologies, the agricultural sector of developing countries is noted for low productivity and output levels. This is particularly why the transformation of agriculture in Africa is seen as necessary to address these challenges with irrigation as one strategy (Mwangi and Crewett, 2019; Nguyen and Nguyen, 2016; Nkhata, 2014; Nonvide, 2018; Passarelli, Mekonnen, Bryan and Ringler, 2018). In their effort to address these challenges, governments of many developing countries have adopted irrigation programmes as sustainable agricultural development strategies. However, literature has shown that despite the heavy investments into modern agricultural technologies, adoption levels are still sub-optimal among farmers in developing nations (Kuwornu and Owusu, 2012; Okyere and Ahene-Codjoe, 2021).

Rice, the second most important staple cereal crop after maize is one of the major crops produced under irrigation in Ghana with a lot of prospects for growth in terms of production and consumption (MoFA, 2009; Ragasa, Dankyi, Acheampong, Wiredu, Chapoto, Asamoah and Tripp, 2013). Rice is grown in all the climatic zones in Ghana but the bulk of it is produced in the northern savannah areas where conditions are relatively more favourable. With about 64% share of the total rice output, northern Ghana is the most important rice-growing area in the country (Ragasa et al., 2013). The Centre for Studies & Strategic Foresight (2012) contends that rice became one of the profitable cash crops in northern Ghana after the collapse of the cotton industry as its cultivation is possible even without access to irrigation systems.

For its higher poverty alleviation and strategic importance in ensuring national food security, northern Ghana may be more appropriate in setting the agenda to address food security and poverty challenges in the country. For instance, the Bill and Melinda Gates Foundation (Bill & Belinda Gates Foundation, 2012) reports that because northern Ghana is the largest rice producer, the Government of Ghana (GoG) has prioritized the region for poverty reduction through boosting rice productivity. In rice producing areas, processing and local marketing of rice are predominantly carried out by women on small scale basis and income from these activities can be used as ways of diversification to improve household nutrition and to meeting household health and educational needs. These processing and marketing activities can contribute to strengthening household food security as income generated from such activities could enable households to have income to buy food when they run out of their own staple stocks before the next crop harvests (Kuwornu and Owusu, 2012). According to Angelucci, Asante-Poku and Anaadumba (2013), rice could go as one food security crop that can be used to address both hunger and poverty in northern Ghana.

Rice production systems comprise of irrigation and rain-fed; and like most other staple crops, rice is produced predominantly by smallholder farmers who cultivate less than one hectare per heard (Angelucci et al., 2013). Productivity of rice ranges between 1 and 1.5 MT/ha on the average, for upland cultivators under rain-fed system; 2 to 2.5 MT/ha for lowland; and 3 to 4 MT/ha for irrigated systems (Gage, Bangnikon, Abeka-Afari, Hanif, Addaquay, Antwi and Hale, 2012). Ragasa et al. (2013) have estimated the national potential yield between 6 and 8 MT/Ha. Increases in rice production over the last decade are reported to have been driven by factors such as increased cropped area being put under irrigation (for all year round production); rice field expansion, and increased use of improved varieties (Gage et al., 2012; MoFA, 2014). In the recent flagship programme of the government of Ghana's Planting for Food and Jobs (PFJs), one main area of concern is to provide the necessary conditions for all year round food production for poverty reduction and food security (MoFA, 2017). The driving strategy to achieve this goal is through the construction of dams to support dry season farming.

Whilst there exists a lot of studies on irrigated agriculture and the resulting impacts for Ghana and elsewhere (Adam, Al-hassan and Akolgo, 2016; Bidzakin, Fialor, Awunyo-Vitor and Yahaya, 2018; Gebrehiwot, Makina and Woldu, 2017; Kuwornu and Owusu, 2012; Mwangi and Crewett, 2019; Nguyen and Nguyen, 2016; Nkhata, 2014; Nonvide, 2018; Okyere and Ahene-Codjoe, 2021), not much has been done in the area of comparative analysis on the impact of joint irrigation and rain-fed production systems. All these studies are largely on irrigation adoption as a modern agricultural technology and its effect on crop yield (Bidzakin et al., 2018; Nonvide, 2018) or on farmers welfare (Adam et al., 2016; Gebrehiwot et al., 2017; Kuwornu and Owusu, 2012; Mwangi and Crewett, 2019; Nguyen and Nguyen, 2016; Okyere and Ahene-Codjoe, 2021).

The study by Bidzakin et al. (2018) evaluated the effect of irrigation ecology on farm household technical, allocative and economic efficiency of smallholder rice farmers in Ghana whilst that of Gebrehiwot et al. (2017) assessed the impact of the irrigation on household welfare using household fixed assets formation and farm income as proxy indicators of welfare. Another irrigation technology related study is by Mwangi and Crewett (2019) which evaluated smallholder African Indigenous Vegetables production and market participation by smallholders. Inspite of the availability of copious empirical studies on irrigation based agricultural production, a research that is designed to assess the effect of the simultaneous adoption of irrigation based crop production and rain-fed production systems is yet top sighted.

It is to contribute to empirical knowledge that this study is designed to analyse the impact of the joint strategy of simultaneous adoption of irrigated and rain-fed rice production systems as a way of all-year round cultivation of rice and its impact on the welfare of smallholder rice producers in northern Ghana. The objectives of the study are therefore to examine the determinants of all-year round rice production and to analyse the impact of all-year round rice production on farm households' food expenditure and poverty status.

## 2. Materials and Methods

### 2.1 Theoretical and Analytical Frameworks

Farmers' decision to engage in all-year round rice production is modeled based on the random utility theory in this study. The theory posits that a farmer decides to do all-year round or continuous rice production, that is, produces rice using irrigation in the dry season and under rain-fed conditions, only if the expected utility to be derived exceeds that from not doing so. It is reasoned that, the farmer's direct expectation in his/her engagement in all-year round rice production is better or higher welfare, in this case, higher household food consumption expenditure per head and lower food expenditure poverty gap. For our analysis, farmers' participation in all-year round rice production becomes the selection criterion which indicates one of two regimes confronted by farmers. Based on previous studies on impact analysis (Abdulai and Huffman, 2014; Issahaku and Abdulai, 2019; Mwangi and Crewett, 2019; Nonvide, 2018), participation in all-year round rice production function can be specified as:

$$R_i^* = \varphi K_i + U_i \qquad 1$$

where $R_i^*$ is a latent variable indicating a farmer's participation status; $K_i$ is a vector of household and farm characteristics which are assumed to affect the farmer's decision with respect to all-year round rice production; φ is a vector of parameters to be estimated and $U_i$ is a random error term. From Equation 1, it follows that a farmer participates in all-year round rice production given that $R_i^* > 0$. Farmers are then grouped as participants if they did engage in all-year round rice production in the crop season under consideration and non-participants if they did not. $R_i$, which is the observable dichotomous variable and which indicates whether or not a farmer is an all-year round rice producer is then defined as follows:

$$R_i = \begin{cases} 1 \text{ iff } \varphi D_i + U_i > 0 \\ 0 \text{ iff } \varphi D_i + U_i \le 0 \end{cases} \qquad 2$$

where $R_i = 1$ indicates that the farmer is an all-year round rice producer and $R_i = 0$ indicates otherwise.

In this study, our interest outcome variables are household food expenditure per capita and food expenditure poverty gap, defined as a linear function of farmers' participation in all-year round rice production together with other observed variables. This translates into a linear regression equation represented by

$$F_i = \alpha X_i + \varphi R_i + V_i \qquad 3$$

where $F_i$ is a vector of welfare indicators (food expenditure per capita and food expenditure poverty gap), $X_i$ is a vector of farmer, household and farm characteristics, α is a vector of parameters to be estimated, $V_i$ is a random error term with $R_i$, φ and $U_i$ as defined earlier.

Estimating the impact of all-year rice production on household welfare using Ordinary Least Squares (OLS) techniques on Equation 3 may lead to biased and inconsistent estimates and thus, rendering the model inappropriate. This might be so because of possible endogeneity problem as farmers' decision to engage in all-year round rice production is assumed to be exogenous by Equation 1. According to Heckman (1979) however, this could be potentially endogenous as farmers' decision to engage in all-year round rice production may be voluntary and could be self-selective. Under such circumstances, the impact of all-year round rice production should be isolated from the observed and unobserved socioeconomic factors that determine farm households' welfare (food expenditure per capita and food expenditure poverty gap). It is often argued that, unobserved factors influencing the participation decision may include farmers' hidden ability and skills $(U_i)$ which could likely correlate with unobserved factors that influence the outcome variable$(V_i)$, and this can result in biased and inconsistent coefficient estimates. As a result, the two regimes of rice producers emerge and can be specified as follows:

Regime 1: $F_{i1} = \alpha X_{i1} + V_{i1}$ participants of all-year round rice producers 4a

Regime 2: $F_{i0} = \alpha X_{i0} + V_{i0}$ non-participants of all-year round rice producers 4b

where $F_{i1}$ and $F_{i0}$ are respectively, welfare indicators of participants and non-participants in all-year round rice production; $X_i\alpha$ and $V_i$ are as defined earlier on.

Given the possibility that some unobserved factors affecting farmers' all-year round rice production decisions could also affect the outcome variables (welfare indicators), the error term in Equation 1 and those in the outcomes equations (Equations 4a and 4b) may be correlated. To address this, a simultaneous equations model of all-year round rice production and welfare indicators are estimated using an Endogenous Switching Regression (ESR) based on a Full Information Maximum Likelihood (FIML) technique following (Asfaw, Shiferaw, Simtowe and Lipper, 2012; Nonvide, 2018).

Using ESR is more popular in impact studies due to its advantage and ability to estimate expected welfare for both participants and non-participants as well as their respective counterfactuals. To this extent, the expected welfare of participants (a) can be appropriately compared to that of non-participants (b). It is also possible to estimate the expected welfare in the counterfactual cases; (c) that participants did not adopt in all-year round rice production and (d) that non-participants did engage in all-year round rice production. The procedure for calculating the conditional expected and counterfactual welfare estimates are presented in Table 1 as indicated by cases (a) through (d) with cases (a) and (b) indicating actual welfare expectations, while the counterfactual expected outcomes are represented by cases (c) and (d).

Table 1. Welfare Expectations, Treatment Effects and Heterogeneity Effects

| Sub-Sample | Decision Stage | | Treatment Effects |
|---|---|---|---|
| | Participate | Do not participate | |
| Participants | (a) $[F_{i1} \vert R_i = 1]$ | (c) $[F_{i1} \vert R_i = 0]$ | TT |
| Non-Participants | (d) $[F_{i0} \vert R_i = 1]$ | (b) $[F_{i0} \vert R_i = 0]$ | TU |
| Heterogeneity Effect | $BH_a$ | $BH_b$ | TH |

Source: Di Falco, Veronesi and Yesuf (2011); Asfaw et al. (2012).

In Table 1, TT is the estimate of the effect of the treatment on the treated, calculated as $TT = E(F_{i1}|R_i = 1) - E(F_{i1}|R_i = 0)$. TT therefore measures the effect of all-year round rice production which is the difference between cases (a) and (c). The effect of the treatment on the untreated (TU), is calculated as $TU = E(F_{i0}|R_i = 1) - E(F_{i0}|R_i = 0)$ and this is the difference between cases (d) and (b) which reflects a situation where non-participants did participate and where they (non-participants) did not participate. To separate the treatment effects from heterogeneity effects arising from the possibility that participants may have more or less welfare than non-participants, regardless of the fact that they participated in all-year round rice production, $BH_a$ is calculated as the base heterogeneity effect using the formula $E(F_{i1}|R_i = 1) - E(F_{i0}|R_i = 1)$. Such difference could rather be due to unobservable factors that affect the farmers' welfare. It is the difference between cases (a) and (d). In contrast, $BH_b$ is the base heterogeneity effect for farmers that did not participate and measured as $E(Y_{i1}|S_i = 0) - E(F_{i0}|R_i = 0)$ which is the difference between cases (c) and (b). Finally, to determine whether or not the effect of all-year round rice production on household welfare is greater or less for participants or for non-participants if they did participate, a Transitional Heterogeneity effect (TH) is calculated by taking the difference between TT and TU $(\mathrm{TH} = \mathrm{TT} - \mathrm{TU})$.

**2.2 Per capita food expenditure as household welfare indicator**

Consumption expenditure provides an indicator of poverty and it encompasses four categories of food; housing, durables, and non-durables (Amanor-Boadu, Zereyesus and Asiedu-Dartey, 2013). In calculating the household food consumption expenditure, the food expenditure category were annualized and aggregated for each household and divided by the number of people in the household to get the per capita food expenditure. We used this measure as a proxy for household welfare, particularly food security following previous studies (Ali and Abdulai, 2010; Amanor-Boadu *et al.*, 2013; Asfaw *et al.*, 2012; Awotide, Awoyemi, Diagne, Kinkingnihoun and Ojehomone, 2012; Bacha, Namara, Bogale and Tesfaye, 2011; Becerril and Abdulai, 2010; Ogundari, 2013; Tongruksawattana, 2014). Thus, increase in per capita food expenditure indicates improved availability and accessibility to food, implying improved food security and hence welfare. However, in generating the food expenditure poverty profiles of households, the Foster-Greer-Thorbecke (Foster, Greer and Thorbecke, 1984) formula was used. The Foster-Greer-Thorbecke formula is expressed as: $P_\alpha(y,z) = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)^{\alpha} \Big| y_i < z$ 5

where:

$z =$ Food expenditure poverty line.

$q$= the number of households below the food poverty line.

$n$= the number of households in the reference population.

$y_i$= per capita food expenditure of the $i^{th}$ household.

$z - y_i$= food poverty gap of the $i^{th}$ household.

$\frac{z-y_i}{z}$= food poverty gap ratio.

$\propto$= food poverty aversion parameter which can take the values 0, 1 and 2

From Equation 5, the Headcount Food Poverty Index (HFPI) is the fraction of the study population who are food poor and this was estimated accordingly. The Food Expenditure Poverty Gap (FEPG), measures the short fall of the per capita food expenditure of the $i^{th}$ household from the adopted food poverty line which is the two-thirds of the mean per capita food expenditure following Awotide *et al.* (2012). Whilst the HFPI is obtained by equating $\propto$ to 1, the FEPG is estimated using the "$z - y_i$" part of Equation 5. In this study, the food poverty line is estimated as the two-thirds of the mean per capita food expenditure of the sampled households (Awotide *et al.*, 2012).

**2.3 Context and data**

Rice farmers in the Guinea Savannah ecological zone consisting of those of the major irrigation schemes as well as those located in areas of vast natural rice valleys constituted the population for this study. Sampling followed a multistage procedure. The first stage was a purposive sampling where two regions (Northern and Upper East) located in the Guinea Savannah ecological zone, were selected. This was informed by their high share of rice output in Ghana (Angelucci *et al.*, 2013) and because the regions have vast natural lowlands suitable for rice production. The regions are also noted for hosting Ghana's major irrigation schemes that have sustained rice production in the country over the years. Rice farmers at the five main irrigation schemes; two in the Upper East Region (Tono and Vea) and three in the Northern Region (Libga, Golinga and Bontanga) were targeted for sampling.

Following a simple random sampling procedure in the next stage, five districts in each of the two regions were selected. Four to seven communities were further selected (depending on the size of the irrigation catchment area) through a simple random method in each of the selected districts in the third stage, resulting in a total of 62 farm communities with 543 rice farmers of which 68% were sampled from the Northern Region and 32% from the Upper East Region. The proportion of the sample assigned to each region was based on the density of rice production points in the two regions, with the Northern Region being dominant in the production of the crop. Preliminary analysis of the completed questionnaire according to the objectives and design of this study, categorised the respondents into three distinct groups: thus, those who produced rice with irrigation only (223), rain-fed only (217) and those who produced under both irrigation and rain-fed conditions (103). As a result, 320 respondents constituted the sample size, and this comprised the last two categories, thus, rain-fed producers and producers under both irrigation and rain-fed conditions.

### 2.4 Summary statistics of variables

Table 2 presents the descriptive statistics and the mean differences in the outcome and other household and farm characteristics between participants in all-year round rice production and non-participants. In particular, all-year round rice producers are significantly different from their counterpart producers in terms of food expenditure poverty gap, food poverty incidence, household head age, level of education, marital status, household size, engagement in non-farm work, mean distance to the nearest market place and farmers' experience in rice farming. Other areas of differences are training and extension visits received by farmers, FBO membership, fertilizer subsidy receipts and land tenancy status.

The data further show that with a mean distance from the food expenditure poverty line of GHS46.17 for all sampled farm households, participants' mean distance from the poverty line (GHS16.03) is significantly lower than non-participants' (GHS60.46), implying that farm households that engaged in all-year rice production are more than 3 times closer to the food poverty line compared to seasonal rice producers in northern Ghana. Also, with only 6.3% of all-year-round rice producers being poor in terms of food expenditure, as high as 23.6% of farmers doing seasonal cultivation are poor and the overall poverty incidence is 18.2%. These findings on poverty reducing effect of irrigated crop production is consistent with earlier studies such as Bacha *et al.* (2011) and Gebrehiwot *et al.* (2017).

Also, with the mean age and level of education of 37 years and 4 years respectively for all sampled farm households, participants' mean age (39 years) and level of education (7 years) are significantly higher than non-participants' mean age (36 years) and levels of education (3 years). These results indicate that all-year round rice producers are older and more educated (middle school leavers) than seasonal rice producers. Higher age and level of education may partly determine access to and use of communal irrigation facilities and adoption of agricultural intensification technologies among farmers in northern Ghana where age and education are revered and influential. Data from Table 2 further indicate significant unequal access to institutional training and information services as well as input subsidies between seasonal and all-year round rice-producing households in the study area. For example, the proportions of all-year round rice-producing households that have access to training and government fertilizer subsidies are 34.7% and 47.6% less than seasonal rice-producing households respectively. Also, on average, seasonal rice-producing households received about 3 more extension services than all-year round rice producers. These suggest that despite the contribution of dry-season rice production to food security, employment and wealth creation, government policy and extension and advisory agencies still appear to focus their services to seasonal rice farming systems.

Table 2. Variables and summary Statistics of respondents

| Variable | Pooled | Participants | Non-Participants | Mean Difference | t-test |
|---|---|---|---|---|---|
| Per capita food expenditure | 380.70 | 383.70 | 379.28 | 4.42 | -0.0803 |
| Food expenditure poverty gap | 46.17 | 16.03 | 60.46 | 4.443*** | 6.3882 |
| Food poverty incidence (%) | 18.2 | 6.3 | 23.6 | -17.5*** | -3.7932 |
| Male farmer (%) | 80.9 | 80.5 | 81.1 | 0.5 | 01111 |
| Age of farmer | 37.26 | 39.43 | 36.24 | -3.20*** | 2.8416 |
| Level of education | 4.28 | 6.90 | 3.02 | -388*** | -7.247 |
| Married farmer (%) | 93.4 | 99.0 | 90.8 | -8.2*** | -2.808 |
| Household size | 9.4 | 6.97 | 10.55 | 3.58*** | 5.2606 |
| Farm size in acres | 3.20 | 2.95 | 3.3 | 0.38 | 0.7092 |
| Non-farm work (%) | 25.6 | 7.76 | 34.10 | 26.33*** | 5.2397 |
| Credit amount | 18.91 | 63.13 | 160.14 | 97.01 | 1.005 |
| Farm-market distance | 6.89 | 4.32 | 8.12 | 3.79*** | 6.089 |
| Contract farmer (%) | 5.3 | 5.8 | 5.0 | -0.7 | -0.2809 |
| Farmers experience | 11.19 | 13.48 | 10.11 | -3.37*** | -3.9628 |
| Training received (%) | 57.5 | 33.9 | 68.7 | 34.7*** | 6.1870 |
| Extension visits | 3.97 | 2.04 | 4.84 | 2.84*** | 4.1226 |
| Farmer Based Organization (%) | 67.5 | 85.4 | 58.9 | -26.5*** | -4.8778 |
| Fertilizer subsidy beneficiary | 46.9 | 14.6 | 62.2 | 47.6*** | 8.8885 |
| Land tenancy (%) | 90.3 | 80.6 | 94.9 | 14.3*** | 4.1484 |
| Number of observations | 320 | 103 | 217 | | |

The data further show that while about 26.5% more of participants belonged to FBOs, proportionally, more seasonal rice producers (47.6%) benefited from government fertilizer subsidy programme. Moreover, participants' mean household size (7 people) is significantly lower than non-participants' (10 people), indicating that though all-year round rice production is more labour-requiring, participating households have lower labour availability potential compared to seasonal rice-producing households. This finding on household size is similar to earlier findings especially Andani (2019) who reported an average of 8 people consisting of a typical household size in farming communities in northern Ghana. The results suggest all-year round rice producers may be relying more on hired labour. Related to this finding is the marriage status of sample. Whilst about 93% of all sampled households were headed by married people, almost all participants in all-year round rice production were married and about 91% of the seasonal rice cultivators were married, according to the data. The higher proportion of married households has implications on labour availability for crop production and hence their high propensity for all-year-round rice farming. A contrary finding is related to household size where seasonal rice producers had larger household size (10) compared to 7 for households doing all-year-round rice production.

In the absence of irrigation opportunities and in the context of northern Ghana where crop cultivation is mainly rain-fed, there is high likelihood for farmers to engage in non-farm work. The data show that about a quarter (25.6%) of all sampled farm households engaged in non-farm work, while about 8% of all-year-round rice farm households compared to 34% for seasonal rice producers. This suggests that more seasonal rice producers are engaged in non-farm income-generating activities, perhaps and partly as a substitute for dry season rice production, than all-year rice farmers.

Further, in terms of proximity to market centres, households engaged in all-year rice farming are approximately 4.3 km away from market centres whilst those doing seasonal production live 8.1 km away from such market centres. This suggests that all-year round rice producing-households are closer to market centres than seasonal rice producers, confirming existing knowledge that market development and efficient distribution system are determinants of irrigation crop production in arid and semi-arid regions. The results also reveal that farmers participating in all-year round rice production are about 3 years more experienced in general farming than non-participants, suggesting that farming experience level may significantly influence farmers' participation in dry season rice production since experience contributes to knowledge, adoption of improved technologies and level of access to resources like water, credit and market information services. These observed significant differences in food expenditure poverty lines, food poverty incidence, and access to critical training and extension services that coincide with household participation status in all-year round rice production is a motivation for empirical investigation.

## 3. Results and Discussion

Table 3 presents the results of the diagnostic tests of the validity of the ESR model. The results show a significant Wald test of independent equations at 1% level for the model estimating farm households' per capita food expenditure. These results therefore imply that the model fits well with the overall explanatory variables. The Wald test of Rho indicates that the null hypothesis of no correlation between the error terms in the selection and outcome equations be rejected and suggests the presence of sample selection bias. This confirms that the estimated ESR is more suitable for the data than OLS and other treatment-effect estimators like inverse-probability-weighting, regression adjustment and propensity score matching models since it is able to correct for sample selection bias and omitted variable problem in the estimates. The estimated coefficients of Rho_1 (0.674 ) and Rho_2 (-0.857) statistically significant at the 5 and 10 percent levels respectively. While the positive coefficient of Rho_1 indicates that unobserved factors that increase households' per capita food expenditure correlate with unobserved factors that increased their probability of participation in all-year round rice production, the negative coefficient of Rho_2 indicates that unobserved factors that increase households' per capita food expenditure correlates with unobserved factors that decrease their probability of participating in all-year round rice production.

Table 3. Diagnostic test for determining the validity of the ESR model

| Type of Test | Statistic |
|---|---|
| Model validity test | Rho_1 = 0.674 (0.293)** |
| | Rho_2 = -0.857 (0.461)* |
| | Wald $Chi^2$ (11) = 218.65 |
| Goodness of fit test | Prob>$Chi^2$ = 0.0000 |
| | Log likelihood = -82.27841 |
| LR test of independent equations | $Chi^2$(1) = 8.82 |
| | Prob>$Chi^2$ = 0.0030 |

The positive and significant coefficient of Rho_1 means a negative selection bias, suggesting that farmers with per capita food expenditure lower than average without all-year-round rice cultivation actually participated in all-year round cultivation. Similarly, the negative and significant coefficient of Rho_2 shows a positive selection bias, implying that households with higher per capita food expenditure than average without engaging in all-year-round rice production, did not actually practise all-year round cultivation (Lokshin and Sajaia, 2004). The implication of these results is that, rice producing farm households in northern Ghana that have lower per capita food expenditure compared to the mean per capita food expenditure are more likely to participate in all-year round rice production. On the other hand, those rice producing households whose per capita food expenditure is higher compared to the mean per capita food expenditure are less likely to do all-year-round rice production. These findings are in consonance with previous findings such as Abdulai and Huffman (2014).

### 3.1 Determinants of all-year-round rice production and farm households' food consumption expenditure in northern Ghana

Table 4 presents the results of the factors that influence farm households' participation in all-year round rice production (column 2) as well as the determinants of farm households' food expenditure (columns 3 and 4). As expected, non-farm work significantly predicts households' participation in all-year round rice production at the 1 percent level. This indicates that non-farm employment, especially during the dry season, is associated with lower probability of participating in all-year round rice production among farm households. Institutional services such as extension, training, and fertilizer subsidy, unexpectedly, correlate negatively with households' participation in all-year round rice production at least at 5 percent significance level. In particular, contact with extension services is important in making information on sustainable food production approaches to farmers and present more opportunities to them to adopt such approaches. This however suggests that households that have access to extension, training, and fertilizer subsidy services are less likely to engage in all-year round rice production and the finding on extension services is inconsistent with Gebrehiwot *et al.* (2017) who found a positive correlation between extension service visits with the adoption of modern crop production technologies that enhance all-year round crop cultivation in Ethiopia. The results further imply that government fertilizer subsidies and extension work and training services are more focused on seasonal rice production in northern Ghana possibly due to the predominance of seasonal rice farmers and the inherent mono-modal rainfall pattern that characterizes the savannah agro-ecological zone. Government policies are, therefore, tailored to favour and enhance productivity of rice producers during the 'main' season to ensure policy efficiency and effectiveness.

Membership with a Farmer-Based Organization (FBO) predicts participation in all-year round rice production positively and significantly, implying that FBO membership increases the probability of a farmer participating in all-year round rice production. This result underscores the potential role community-based farmer organizations play in facilitating access to market information and training services that improve knowledge and skills of farmers on sustainable intensification and dry season crop production systems. This therefore suggests that improving access to community-based farmer organizations among farmers can contribute significantly to moving farmers from seasonal to all-year round production levels by addressing marketing, funding, and productivity constraints. This finding however contradicts that of Mwangi and Crewett (2019) who found a decreasing effect of membership of farmer groups on the probability of adopting irrigation based vegetable production in peri-urban Kenya.

The socio-demographic characteristics such as education level, household size, marital status, years of farming experience also significantly predict the likelihood of a household to participate in all-year round rice production. Thus, while years of farming experience and educational level of a farmer increase the likelihood of participation in all-year round rice production, larger households are less likely to participate in all-year round rice production. The strong positive effect of education and farming experience to participation in all-year round rice production is consistent with existing findings that education and farming experience improve farmers' management efficiency and skills (Djanggola, Basir, Anam and Ichwan, 2021; Mwangi and Crewett, 2019). Larger households, however, reduce the probability of participation in all-year round rice production and this finding is unexpected as engaging in all-year round food production would require high labour input even though the finding confirms the finding of Mwangi and Crewett (2019) . Under imperfect labour markets such as those found in developing economies, farmers may more likely depend on family labour (Gebrehiwot *et al.*, 2017).

Table 4. Endogenous Switching Regression Estimates: Determinants of all-year round rice production and its impact on farmers' welfare

| Variables | Participation Model | Per Capita Food Expenditure Model | |
|---|---|---|---|
| | | Participants | Non-Participants |
| Male farmer | 0.0251 (0.281) | 0.0569 (0.0370) | 0.0390 (0.0599) |
| Age of farmer in years | 0.0131 (0.0692 | -0.00881 (0.0117) | -0.0247 (0.0154) |
| Age squared | -0.000195 (0.000794) | 0.000149 (0.000133) | 0.000306 (0.000179)* |
| Education level of farmer | 0.0873 (0.0246)*** | 0.00790 (0.00423)* | -0.00678 (0.0075) |
| Household size | -0.0569 (0.0270)** | -0.0529 (0.00545)*** | -0.0273 (0.0041)*** |
| Farm size in acres | -0.0142 (0.0464) | 0.0344 (0.0118)*** | 0.0155 (0.0068)** |
| Credit amount | 6.27e-05 (0.000226) | 0.000103 (6.94e-05) | -2.02e-05 (3.64e-05) |
| Farm-market distance | -0.0293 (0.0304) | -0.00476 (0.00569) | 0.00340 (0.00493) |
| Contract farming | 0.223 (0.376) | 0.335 (0.0902)*** | 0.0922 (0.112) |
| Married farmer | 1.468 (0.759)* | -0.145 (0.142) | -0.130 (0.0984) |
| Non-farm work | -1.130 (0.313)*** | 0.152 (0.0846)* | 0.0871 (0.0636) |
| Farmer experience | 0.0647 (0.0184)*** | | |
| Training | -0.709 (0.284)** | | |
| Extension visits | -0.0693 (0.0228)*** | | |
| Farmer Based Organization | 1.213 (0.281)*** | | |
| Received fertilizer subsidy | -0.518 (0.224)** | | |
| Land ownership | -1.313 (0.400)*** | | |
| Constant | -1.222 (1.368) | 2.874 (0.258)*** | 3.083 (0.301)*** |
| Observations | 320 | 103 | 217 |
| rho_1 | 0.674 (0.293)** | | |
| rho_2 | -0.857 (0.461)* | | |

***, ** and * indicates statistical significance levels at 1, 5 and 10% respectively. Standard errors are in parentheses.

Important factors determining farm households’ food consumption expenditure, from the results (Columns 3 and 4 of Table 4), in all-year round and seasonal rice producing farm households are household size and farm size. Additional significant determinants of food consumption expenditure in all-year round rice producing households are education, contract farming and non-farm work. Household size had a negative effect on household food consumption expenditure whilst farm size had a positive effect. The negative effect of household size is in line with intuition as larger households may tend to have higher dependency burden compared to smaller households and thereby resulting is reduced per capita consumption expenditure. This finding about household size and consumption expenditure agrees with previous empirical findings that, larger households are more likely to have lower welfare status (Nguyen, Phung, Ta and Tran, 2017; Okyere and Ahene-Codjoe, 2021; Tambo and Wünscher, 2016; Teka and Lee, 2020). In a related study of the determinants of vulnerability of rural poverty in Nigeria, Ogebe, Adejo and Burbuwa (2020) found that lower household size is associated with low vulnerability to poverty. Households that have larger farm lands had higher per capita food consumption expenditure, implying that they had a comparative advantage in food production that could naturally translate into higher food stock for family use compared to households with smaller farm lands. Contract farming, non-farm work and education level were found to contribute to higher per capita food expenditure of households engaged in all-year round rice production. All three variables tend to increase household income, thereby expanding the ability to provide adequate food items to feed members of their households. In particular, the finding about non-farm work and household welfare finds support in Teka and Lee (2020) who found a strong positive correlation between participation in non-farm activities and welfare of smallholder farmers in Ethiopia.

### 3.2 Impact of all-year round rice production on farm household welfare in northern Ghana

The effect of all-year round rice production on farm households’ welfare in northern Ghana is presented in Table 5. The study estimated the expected per capita food expenditure under the factual and counterfactual regimes of participation and non-participation in all-year round rice production.

Table 5. Expected per capita food expenditure of all-year round rice production

| Sub-Sample | Decision Stage | | Treatment Effects |
|---|---|---|---|
| | Practised all-year round production | Did not practise all-year round production | |
| Participants | (a) 364.00 (19.555) | (c) 179.79 (5.127) | TT=184.21 (11.961)*** |
| Non-Participants | (d) 894.12 (647.435) | (b) 266.39 (7.535) | TU=627.73 (646.754) |
| Heterogeneity Effects | $BH_1$=-620.12 (940.612) | $BH_2$=-86.61 (11.499)*** | TH=-355.83 |

The results show that the observed per capita food expenditure for participants (GHS 364.00) and non-participants (GHS 266.99) as indicated in cases (a) and (b) respectively are significantly different at the 1% level based on a test of difference of means (t-test). The estimated mean per capita food expenditure for participants in the counterfactual case (c), that is, if they had not participated is GHS179.79. The results suggest that farmers who participated in all-year round rice production are better off as their observed per capita food expenditure (GHS 364.00) is much higher than their counterfactual per capita food expenditure of GHS 179.79. This is demonstrated by the positive significant difference of the Treatment on the Treated (TT) at the 1% level [184.21 (11.961)]. This finding is consistent with earlier findings of a positive impact of agricultural technologies that provide opportunities for all-year round crop cultivation on the poverty status of smallholder farmers (Amfo, Abdul-Rahaman and Issaka, 2021; Babatunde, Opeyemi, Adenuga, Olagunju and Aminou, 2013; Gebrehiwot *et al.*, 2017). The results further show that, the average per capita food expenditure of non-participants would have been GHS 894.12, had they decided to do all-year round rice production. When compared with their observed per capita food expenditure of GHS 266.79, non-participants would have been better off if they had participated. However, there is no significant difference between the observed and counterfactual estimates of the per capita food expenditure for non-participants. This finding about non-participants could be attributed to the possibility of inaccessibility of this group to dry season farming opportunities. In summary, the study finds that while engaging in all-year round rice production has a positive and significant effect on farm households' welfare (per capita food expenditure), non-participants could be better off if they had participated. Their non-participation could be due to lack of irrigation facilities in close proximity to them.

## 4. Conclusion and Recommendation

In this study an ESR approach was used to estimate the impact of all-year round rice production on farm households' welfare in northern Ghana. The use of the ESR was informed by its ability to control for bias due to the observed and unobserved factors. The study found that education, farm size, marital status, household size, non-farm work, training, extension visits, FBO membership, farmers' experience, land ownership status and the use of subsidized fertilizers were the important factors influencing the practice of all-year round rice production. The study also found that engaging in all-year round rice production enhances household food expenditure and hence welfare. Other important variables such as farmers' educational level, farm size, contract farming and non-farm work have positive effect on household welfare whilst household size has a negative effect the welfare of farm households. These findings imply that whilst engaging in all-year round rice production is important for increasing farm households' welfare, the provision of support services such as ready market in the form forward contract and creating rural non-farm work opportunities could complement efforts to improve rural livelihoods. The study therefore recommends that expanding irrigation infrastructure in northern Ghana could be effective in the fight against food and nutrition security in the country. Future and further empirical research could explore the link between all-year round crop production and other household welfare indicators such as household asset and household dietary diversity.

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