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# Baseline Study on Fertilizer Use and Food/Nutrition Security in the Sudan Savannah, Guinea Savannah, and Transitional Zones of Ghana

## IFDC FERARI Research Report No. 5

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# ABBREVIATIONS

| | |
|---|---|
| AS | Ammonium Sulfate |
| AWHC | Available Water-Holding Capacity |
| CEC | Cation Exchange Capacity |
| CFSVA | Comprehensive Food Security and Vulnerability Analysis |
| HDDS | Household Dietary Diversity Score |
| FBO | Farmer-Based Organization |
| FAO | Food and Agriculture Organization of the United Nations |
| FERARI | Fertilizer Research and Responsible Implementation |
| GAIP | Ghana Agricultural Insurance Pool |
| GHI | Global Hunger Index |
| GHS | Ghana cedi |
| GoG | Governments of Ghana |
| HDDS | Household Dietary Diversity Score |
| HFIAS | Household Food Insecurity Access Scale |
| ICT | Information and Communication Technology |
| MoFA | Ministry of Food and Agriculture |
| ODK | Open Data Kit |
| PCA | Principal Component Analysis |
| PFJ | Planting for Food and Jobs |
| PPI | Poverty Probability Index |
| RTS | Return to Scale |
| SDG | Sustainable Development Goal |
| SFA | Stochastic Frontier Analysis |
| SMS | Short Message Service |
| OC | Organic Carbon |
| VSLA | Village Savings and Loan Associations |
| WFP | World Food Programme |

# SUMMARY

Smallholder farmers play a significant role in ensuring the food security of Ghana. With current productivity shortfalls, improving crop yields is a major concern to many agricultural stakeholders. The challenges to productivity improvement may be enormous, as it requires an integrated approach. However, declining soil fertility remains a key issue. The Government of Ghana (GoG) over the years has rolled out various fertilizer subsidy programs to enhance the use of inorganic and organic fertilizers. Yet according to the tenet of the FERARI program, the widespread adoption of appropriate fertilizers requires a transformation of the fertilizer sector and food systems that must be driven by evidence-based agro-technical perspectives. Therefore, baseline information on farming in the Transitional and Guinea Savannah zones of Ghana was collected from 1,450 farmers. Objectively, this report provides information on the farmers and farm characteristics, fertilizer use and crop responses, food security, and poverty in the study regions.

- The study established that access to institutional inputs, such as credit and extension services, was low among the farmers. Most of the farmers cultivated no more than 2 hectares (ha) of land area, with more area allocated to maize than to rice and soybean.
- There was low adoption of integrated agronomic practices by the farmers, which may have implications for their farm yields. Contrary to the subsistence connotation with smallholders, many farmers in this study cultivating maize, rice, and soybean sell their produce rather than using it directly for home consumption. However, concerns over market and prices remain crucial for the commercialization of agriculture.
- About 80% of the farmers used at least one type of fertilizer during the 2019 production season. The main fertilizers used by the farmers were NPK 15-15-15, urea, and ammonium sulfate (AS). NKP 15-20-20+0.7Zn was also used by about one-fifth of the farmers and was promoted under the GoG's flagship Planting for Food and Jobs (PFJ) program. A lack of funds, coupled with low credit access, was the major challenge to fertilizer use by the farmers.
- The intensity of fertilizer use was influenced by several factors, particularly extension access, credit access, Poverty Probability Index (PPI), labor, perception of soil fertility, and region.
- Farmers indicated their desire for fertilizer and other production-related information through information and communication technology (ICT), such as SMS, social media (WhatsApp), and direct phone calls.
- The Household Dietary Diversity Score (HDDS) was an average of 7.6 in a range of 1-12, which represents moderate dietary diversity for the majority of the farmers. Dietary diversity was highest in Upper East Region and lowest in North East Region. According to the Household Food Insecurity Access Scale (HFIAS) index, about 18% of the farming households were severely or moderately food insecure. To cope with food insecurity, farmers relied on lower quality foods or less preferred foods.
- The use of fertilizer led to positive impacts on maize, rice, and soybean yields. Although there were lower fertilizer application rates than recommended and regional disparities in the impacts of fertilizer on yields, it was generally observed that there were differences in yield for NPK combined with S and NPK combined with Zn. However, there is the need to further evaluate these yield difference under a controlled trial, in which the application rate of both fertilizer formulations can be better studied.
- Overall, yield increase due to fertilizer use was low at only around 5-10 kilograms (kg) of maize grain per kilogram of N applied, compared to 40 kg of grain per kilogram of N applied

in developed nations. Similar low responses hold for other nutrients, suggesting other factors depress yield more heavily than fertilizer use.

- Although farmers who use fertilizers indicate their importance for increasing yield, no difference in HFIAS was observed between farmers that used fertilizers and those that did not.
- There was no significant difference in yield between farmers who purchased fertilizers at subsidized prices and those who purchased at commercial prices. Farmers who broadcast fertilizer had lower yields for all crops than those who did not. Also, farmers who indicated applying the recommended fertilizer type at the right time had higher yields than those who did not. Maize farmers who applied fertilizer at the recommended rate had higher yields than those who did not, which was not the case for rice and soybean farmers.
- The average annual income of the sampled farmers was GHS 6,597 compared with an average household food expenditure of GHS 6,915. The major source of income for many households was farm income. Therefore, improving the farm returns of the farmers would mean that their standard of living would be improved.

The results provide a set of indicators for monitoring under the FERARI program. These include farm productivity (crop area, crop yields, and farm income), farm output handling (access to market, sales, and consumption volumes), production factors (fertilizers, improved seeds, labor use and labor productivity, and integrated agricultural practices), food security and poverty (HFIAS, HDDS, and poverty levels), and information and support (access to extension services, credit, and subsidized inputs [particularly fertilizer]).

# CHAPTER 1: INTRODUCTION

## 1.1 Background

Poverty and hunger (food insecurity) are daunting challenges that many countries across the globe face. Unsurprisingly, ending poverty and hunger are the first and second in the 17 globally agreed-upon Sustainable Development Goals (SDGs). This calls for continued redesign of policies and programs to minimize or eliminate these challenges. Although Ghana continues to make progress in reducing both poverty and hunger, the incidences are still high. With 23.4% poverty (GSS, 2018), about one in every four to five Ghanaian households lives below a decent standard of living. A significant proportion (39.5%) of these poor people live in rural areas, where inequality continues to worsen. This is concerning because the rural areas are home to farmers whose production plays a significant role in the food security of the country.

Ghana recorded an index of 15.2 in the 2020 Global Hunger Index (GHI), which indicates that the country is moderately food secure (von Grebmer et al., 2020). This is not unlike the situation worldwide, in which hunger is at moderate level. The 2012 Comprehensive Food Security and Vulnerability Analysis (CFSVA) of northern Ghana shows that 680,000 people were considered either severely or moderately food insecure (WFP, 2012). Specifically, 28%, 16%, and 10% of the people in Upper East, Upper West, and Northern regions were severely or moderately food insecure. The assessment indicates that the poorer households and those with smaller farms had higher food insecurity.

The important role of agriculture in the socioeconomic development of Ghana goes unquestioned. For SDG 2, increasing production, productivity, and the resilience of production systems in the changing production environment, i.e., climate change and population pressure, is vital as a basis for improving farm income and reducing poverty (SDG 1). Unfortunately, there are large yield gaps between realized and potential yield of almost all crops in the country, which provide the scope for productivity increase. One reason for these gaps is declining soil fertility. Therefore, doubling or even tripling of crop production means that the farmers must integrate external soil fertility improving strategies, such as inorganic fertilizers, in their soil fertility management practices.

Evidence shows that the application of inorganic fertilizer improves crop yields, such as for maize in Ghana (Bua et al., 2020). Also, more food must be produced on the current cropland, or even less cropland in the future, to reduce expansion of agriculture into more lands at the expense of biodiversity and increased emissions of greenhouse gases. Over the years, GoG has introduced subsidized fertilizer programs with the aim of boosting crop production in the country. While fertilizer use is increasing in Ghana (Odionye et al., 2020), the use per hectare of land is still low. The favorable agricultural and fertilizer policies and programs of the GoG create an opportunity for IFDC to assist in increasing the effectiveness of these programs for enhanced impact on reducing hunger and poverty, given its specialized expertise on soil fertility management and value chain development (https://ifdc.org/strategy-2020-2030/).

IFDC's global vision is to empower farmers and agribusinesses along the food value chain through independent and innovative fertilizer and soil fertility research, technology transfer, agricultural policy advocacy, and market development. Several IFDC programs have shown that farmers who use recommended fertilizers obtain a significant improvement in yield; such gains must be scaled up and consolidated. One IFDC program that has been recently launched to this aim is the Fertilizer Research and Responsible Implementation (FERARI) program (https://ifdc.org/projects/fertilizer-research-and-responsible-implementation-ferari/).

The FERARI program recognizes that the widespread adoption of appropriate fertilizers requires a transformation of the fertilizer and food systems that must be driven by evidence-based agro-technical perspectives embedded in multi-stakeholder processes to create enabling conditions for adoption. The systematic approach should support widespread adoption of balanced fertilizers by farmers in Ghana to improve their food and nutrition security. Prior to the enrollment of specific activities under the program and to provide a basis to robustly assess impacts later, there is a need to establish baseline data. Therefore, this study was conducted in the Guinea Savannah, Sudan Savannah, and Transitional zones of Ghana to understand current fertilizer use and food and nutritional conditions of farm households.

## 1.2 Objectives of the Study

The primary objective of this study is to provide baseline information on the fertilizer use and food and nutritional security of farm households. The specific objectives and associated indicators are outlined in this overview.

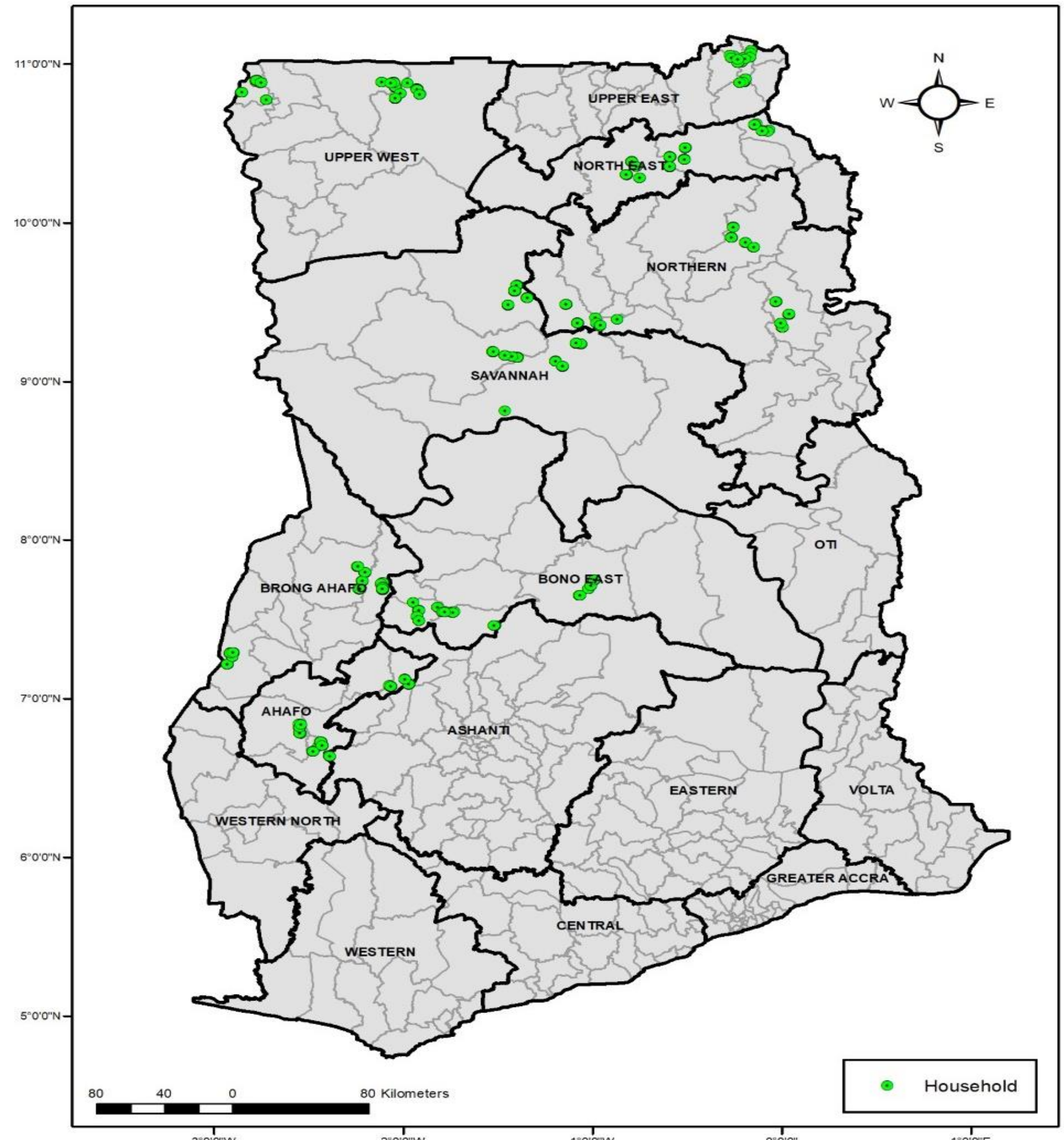
| Objective | Indicators |
|---|---|
| 1. Analyze the food and nutritional security status of households and their strategies to cope with food security/insecurity | i. Food consumption expenditure<br>ii. Own produce consumption (own farm food adequacy/gap)<br>iii. Household Food Insecurity Access Scale (HFIAS)<br>iv. Household Dietary Diversity Score (HDDS)<br>v. Food (in)security coping strategies |
| 2. Analyze the crop production structure of households and the type(s) of fertilizer used for the production of various crops | i. Adoption of sustainable agricultural practices<br>ii. Crops produced and fertilizer (and other inputs) usage per hectare under each crop<br>iii. Crop yields and outputs (production volume)<br>iv. Socioeconomic characteristics (e.g., gender, age, education/training, income, and farmer-based organization [FBO] membership) of farmers in relation to the use of each fertilizer type |
| 3. Assess marketing and commercialization of farms | i. Farm revenue<br>ii. Access to output market<br>iii. Farm output handling (sales volume, home consumption volume, post-harvest losses) |

| | |
|---|---|
| 4. Understand farmers' motivation for adoption or non-adoption of existing fertilizer types | i. Reasons/motivations for farmers' decision to use or not use fertilizers<br>ii. Challenges of fertilizer adoption<br>iii. Whether (from farmers' perception) the current fertilizers used by the farmers meet their expectations (e.g., expected increase in output) |
| 5. Analyze the impact of fertilizer on poverty status of farmers | i. Poverty Probability Index (PPI)<br>ii. Effect of fertilizer application (or price difference between subsidized and commercial fertilizers) on PPI |

# CHAPTER 2: METHODOLOGY

## 2.1 Description of Study Location

The study was conducted in the Guinea Savannah and Transitional zones of Ghana. This covers eight regions of Ghana, i.e., Ahafo, Bono, Bono East, Northern, North East, Savannah, Upper East, and Upper West, which are the operational areas of FERARI. These regions are predominantly agrarian and the food hubs of the country. Also, the districts in each region that were considered were those that benefited from the GoG's Planting for Food and Jobs (PFJ) program. Figure 1 shows the map of Ghana and the selected household points.




Dots represent a cluster of households interviewed.

***Figure 1. Spatial distribution of surveyed households***

## 2.2 Sampling Design and Data Collection

*Enumerator training workshop*

The respondents for this baseline study were selected through a multistage sampling procedure. In the first stage, three districts that benefited from the PFJ program in the 2019 cropping seasons and that had the highest supply of fertilizer under the PFJ in the region (Dogor et al., 2020) were selected to ensure that much of the information on use of fertilizer during the 2019 cropping season was considered in the study. In the second stage, a convenient sampling procedure was used in selecting at least four communities in each selected district. Specifically, the field supervisors selected communities that were noted for crop production and were also accessible by the research team. With assistance from field supervisors, the enumerators selected communities within the districts along different geographical points from the district capital. This ensured that communities were not selected along the same route to the district capital and allowed much dispersion of the communities within a district. In the third and final stage, a total of 15 farm households were selected using systematic random sampling. The enumerators were directed to skip at least one household in between sampled households. However, during the survey, more than 15 households were selected from some communities because these extra household members insisted that they were included in the study. In other communities, less than 15 households were sampled due to the failure of enumerators to communicate among themselves about how many each of them interviewed in a community. Table 1 shows the distribution of the sample households in each district.

*A farmer interview at Namangu*

To minimize the risk of COVID-19 for both the enumerators and respondents/participants, focus group discussions were not conducted. Instead, key informant interviews were conducted in each sampled community. The key informants were farmers who have much knowledge on crop production and fertilizer use in their communities.

The individual household data were collected using a structured questionnaire. The questionnaire was designed and reviewed using input from researchers involved in the study. The finalized questionnaire was coded into Open Data Kit (ODK), a computerized data collection system. This ensured that the data manager had real-time access to the data collected on daily basis. As such, errors could be quickly detected and corrected. Information from key informant interviews was also collected using checklists to record their responses to a a set of questions.

*Farmer interview at Zang*

The enumerators for the study were recruited from the selected regions. However, the majority were recruited from Tamale since there was evidence that these enumerators were experienced. The enumerators were taken through an introduction session. During this session, the objectives of the baseline study, the questionnaire, and the roles of the enumerators were explained. Input from the enumerators was considered in revising the questionnaire for piloting. The pilot study was conducted in Kumbungu District of Northern Region. The results of the pilot study were used in finalizing the questionnaire. Most importantly, codes for the open-ended questions were generated from the pilot study.

*Table 1. Number of households selected by districts*

| Region | District (#) | Communities Selected | Number of Households |
|---|---|---|---|
| Northern | Tolon | Chirifoyili, Gbulahagu, Tuunayili, and Yipelgu | 60 |
| | Gushegu | Gbambu, Salaa, Wantugu, and Yawungu | 60 |
| | Yendi | Gbungbaliga, Choo, Malzeri, and Zang | 60 |
| North East | East Mamprusi | Boayinin, Bongbini, Kasaape, and Namangu No. 2 | 60 |
| | Bunkprugu | Konmung-Gberuk, Kunkonmon, Nanpontbauk, and Sayegu | 60 |
| | West Mamprusi | Bugyapaala, Kata, Kukua, and Sayoo | 62 |
| Savannah | North Gonja | Darisalam, Dissah, Lingbinsi, and Tidropei | 60 |
| | Central Gonja | Larigbani, Saankungyili Yapei Yapala, and Yapei Zowu | 60 |
| | West Gonja | Bidima, Bukari Kura, Kojo Kura, and Simpini | 60 |
| Upper East | Pusiga | Deega, Laartega, Ninkogo, and Sarabogo | 60 |
| | Bawku Municipal | Gozesi, Kpalweg, Yaakut, and Zabugu | 59 |
| | Garu | Kpalwega, Kugzua, Namboko, Napaad, and Siigur | 61 |
| Upper West | Sissala West | Buoti, Pulima, Sibelle and Sorbelle | 60 |
| | Nandom | Dondometeng, Gengenkpe, Guo, and Puffien Baagangn | 60 |
| | Sissala East | Chichang, Chinchang, Kong, Nankpawie, and Taffiasi | 60 |

| Region | District (#) | Communities Selected | Number of Households |
|---|---|---|---|
| Bono | Wenchi | Asuano, Beposo, Droboso, and Yoyoano | 61 |
| | Dormaa Municipal | Atesikrom, Duasidan, Kofiasua, and Suromani | 60 |
| | Tain | Bepoayase, Badu, Tainso, and Yabraso | 62 |
| Bono East | Techiman Municipal | Akisimasu, Aworopataa, Bamiri, and Fiaso | 58 |
| | Nkoranza South | Ahyiayem, Akumsa Dumase, Bonsu, and Koforidua | 68 |
| | Atebububu/Amantin | Atebubu, Jato Zongo, New Konkrompe, and Sanwaky | 59 |
| Ahafo | Asunafo North | Asuadai, Kukuom Tanoso, Nkrankrom, Nyamebekere, and Nyamebekyere Nkwanta | 61 |
| | Tano South | Breme, Kwasu, Mansin, and Nyinasua | 60 |
| | Asunafo South | Dantono, Kukuom Tanoso, Siana, and Yankye | 59 |
| **Total** | | | **1,450** |

## 2.3 Data Analysis

The data were analyzed using descriptive statistics to understand the patterns in the data. This involved the estimation of means and percentages. The analyses were done at pooled data level and, when necessary, regional analyses were done.

Regression analyses were also estimated to determine the factors that influence fertilizer use and key outcome variables. Specifically, tobit regression was estimated to understand the factors that influence fertilizer use intensity by farmers, while a Stochastic Frontier Analysis (SFA) was fitted to determine the effect of fertilize use on farmers' yields.

# CHAPTER 3: SOCIO-DEMOGRAPHIC CHARACTERISTICS AND ACCESS TO SOCIAL AMENITIES BY HOUSEHOLDS

## 3.1 Socio-Demographic Characteristics of Farmers

Table 2 shows the socio-demographic characteristics of the sampled farm households. The data show that 82% of the sampled farmers were males, with 86% and 82% being married and natives of their communities, respectively. Marriage and nativity guarantee labor and access to communal resources, such as land, for agricultural production. The dominance of males is expected, given that farm ownership is higher among males than females.

With respect to social capital, the data show that 25% of the respondents were members of a farmer-based organization (FBO), while 26% and 27% of the sampled farmers held a leadership position in any association or in the community and had a relationship with political leaders, respectively. Through their networks, farmers who are related to political figures or leaders are more likely to receive information on agricultural inputs early, since they are often the first contact into the community. Also, farmer leaders tend to drive the activities of their groups and often serve as a contact for their groups as well as a trainer of trainers. About 57% of the respondents were affiliated with a political party. This can have an influence on the success of agricultural policies and programs, since politically affiliated farmers may wholeheartedly support agricultural policies and programs introduced by their political party. Relatedly, Poulton (2014) expressed that there are positive incentives for African governments to invest in agriculture if they are sure of maintaining power.

About 46% of the farmers were engaged in other economic activities outside crop farming. Participation in other economic activities generates extra revenue for the households that may be invested in modern agricultural technologies to boost productivity, with subsequent improvement in welfare outcomes, or used for other social services, such as medical care or education. For example, Anang (2019) estimates that engagement in off-farm activities has a positive impact on the rice productivity of farmers in northern Ghana, while Danso-abbeam et al. (2017) calculated that off-farm activities lead to an improvement in the technical efficiency of maize production in northern Ghana. However, participation in off-farm activities also means that the farmer has to share resources, such as labor and time, between farm and off-farm activities, and this may have a negative effect on farm outcomes.

With respect to the continuous variables, the results show that the sampled farmers were relatively young (44 years old). The average age of a farmer in the sample is consistent with the national average age of 45 (GSS, 2019b). The data also show that about 30% of the farmers are youths (less than 35 years old). The relatively high youth participation in agriculture suggests that farmers in our sample are more likely to work on-farm in the next decades, especially if there are innovative and attractive policies to keep them farming. This also supports GoG's priority of youths under the PFJ program. On average, the farmers had five years of education. Considering that education is crucial in improving human capital and human development, the level of education of the farmers was low, which is not surprising since smallholder farmers in Ghana usually have low formal education. For instance, 56.5% of farmers had up to six years formal education and 18.4% had no formal education (GSS, 2019a).

The average household size was 10, which is greater than the national average of about four (GSS, 2019b) and about seven for agricultural households (GSS, 2019a). This implies that farm households in our surveyed regions were generally larger than the national average, while the large standard deviation indicates an even greater difference in household size. An average household consisted of about five males and five females, with about seven dependents. The high number of dependents has implications on agricultural production decisions and resource mobilization/pooling. Table 2 shows that less than one member in each of the sampled households had migrated to another community or area for off-farm job opportunities.

*Table 2. Descriptive statistics of the socio-demographic characteristics of farm households*

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| ***Dummy variables*** | | | | |
| Gender (1=Male) | 0.82 | 0.39 | 0 | 1 |
| Marital status (1=Married) | 0.86 | 0.35 | 0 | 1 |
| Nativity (1=Native) | 0.82 | 0.39 | 0 | 1 |
| FBO membership (1=Member) | 0.25 | 0.43 | 0 | 1 |
| Holds leadership position (1=Yes) | 0.26 | 0.44 | 0 | 1 |
| Related to political figure (1=Yes) | 0.27 | 0.44 | 0 | 1 |
| Affiliated with a political party (1=Yes) | 0.57 | 0.50 | 0 | 1 |
| Other economic activity (1=Yes) | 0.46 | 0.50 | 0 | 1 |
| ***Continuous variables*** | | | | |
| Age | 44.3 | 12.75 | 18 | 87 |
| Total household size | 10.4 | 7.43 | 1 | 44 |
| Male household members | 5.5 | 4.75 | 1 | 44 |
| Female household members | 5.1 | 4.52 | 1 | 44 |
| Dependents | 7.4 | 5.70 | 0 | 49 |
| Years of formal education | 4.5 | 5.06 | 0 | 16 |
| Migrated to other communities | 0.2 | 0.70 | 0 | 7 |
| Migrated for non-farm job | 0.8 | 1.42 | 0 | 15 |

## 3.2 Nearness to Social Amenities

Table 3 reports the presence of social amenities and financial resources that facilitate agricultural production and commercialization decisions in the communities and, if these are absent, the distance the farmers traveled to access (reach to the location of the amenity) such services or amenities. Distance to the nearest amenities is measured in walking minutes. In terms of access, about 78%, 87%, and 45% of the sampled farmers were located in communities that were connected with all-weathered roads, had pipeborne or borehole water, and had input distribution shops in their communities, respectively. Farmers without input shops in their communities walk for about 104 minutes to the nearest input shop, and this can negatively affect on their use of inputs, such as fertilizer, improved seeds, and weedicides. Having a connecting motorable road to the community is an important factor in the marketing of agricultural products, especially for transporting goods from the communities to the peri-urban centers where there is a ready market and prices may be favorable for the farmers. The results show that 28%, 53%, and 90% of the farmers had a credit facility, a health center, and a school (at least for basic education), respectively, present in their communities. On average, farmers who did not have a credit facility in their communities walk for about 133 minutes to the closest financial institution to access credit.

The data further show that 21% and 18% of the sampled farmers have the district capital's administrative office and extension office, respectively, located in their communities. For those who did not have these institutions located in their communities, they had to walk for 195 minutes and 171 minutes to get to the district capital's administrative and extension offices, respectively. These institutions play an integral role in agriculture. The current administrative structure allows the district capital to initiate agricultural intervention programs; therefore, farmers who are close to such facilities may be readily supplied with information and other technical support to boost agricultural production. The availability of an extension office in the community means that most of the extension staff may reside in the community and farmers can easily walk to the office or to the officer's home for information on agricultural activities. Similarly, this can help address the lack of adequate logistical support to agricultural extension officials that often limits their contact with farmers.

***Table 3. Descriptive statistics of access to social amenities***

| | Presence of Amenity | | | | Walking Distance to Nearest Amenity | | | |
|---|---|---|---|---|---|---|---|---|
| **Variable** | **Mean** | **Std. Dev.** | **Min** | **Max** | **Mean** | **Std. Dev.** | **Min** | **Max** |
| All-weather road | 0.78 | 0.4 | 0 | 1 | 48.7 | 51.6 | 0 | 360 |
| Pipeborne/borehole water | 0.87 | 0.3 | 0 | 1 | 40.8 | 54.9 | 0 | 400 |
| Input (e.g., fertilizer) distribution shop | 0.45 | 0.5 | 0 | 1 | 104.1 | 93.9 | 0 | 840 |
| Credit facility | 0.28 | 0.5 | 0 | 1 | 133.4 | 114.7 | 0 | 974 |
| Health center | 0.53 | 0.5 | 0 | 1 | 107.6 | 99.7 | 0 | 600 |
| Primary school | 0.90 | 0.3 | 0 | 1 | 52.9 | 68.5 | 0 | 360 |
| District capital | 0.21 | 0.4 | 0 | 1 | 195.1 | 255.2 | 0 | 2,880 |
| Extension office/MoFA office | 0.18 | 0.4 | 0 | 1 | 170.8 | 174.2 | 0 | 1,360 |

*Note: Distance is measured in walking minutes.*

# CHAPTER 4: CROP PRODUCTION, MARKETING, AND COMMERCIALIZATION OF FARMS

## 4.1 Farming Characteristics of the Farmers

The summary of farming characteristics is reported in Table 4. On average, farmers had been farming for 21 years. About 40% of the farmers had received extension service, and on average, these farmers were visited about three times by extension agents during the production season. With respect to farm insurance, only about 3% of the farmers have insured their farms against risks, such as droughts. About 53% of the farmers who did not insure their farms, however, were willing to do so. Of this 53%, 0.3% were not willing to pay for the insurance and the remaining 99.7% were willing to pay an average annual premium of GHS 21.9 per acre (GHS 55/ha). This is higher than the area yield index and weather-index insurance premiums in Upper West that were set by Ghana Agricultural Insurance Pool (GAIP) at GHS 10/ha (Adiku et al., 2017). The Food and Agriculture Organization of the United Nations (FAO, 2017) indicates that although insurance is an important tool for poverty alleviation, agricultural insurance in developing countries is either unavailable or expensive.

About 20% of the respondents were engaged in contract farming and 50% of those who were not were willing to participate in it. The results clearly show that most farmers are willing to insure and engage in contract farming as a strategy for minimizing the high risk of crop failure, as farmers depend on rainfall for crop production. About 10% of the farmers received credit for their crop production during the production season. For farmers who received credit, an average of GHS 1,087 was received over the previous year, although there was wide deviation in the credit received.

*Table 4. Descriptive statistics of farming characteristics of the farmers*

| Farm Characteristic | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Years of farming (years) | 21.0 | 12.3 | 1 | 65 |
| Access to extension services (1=yes) | 0.44 | 0.5 | 0 | 1 |
| Number of extension visits per cropping season (#) | 3.4 | 3.1 | 1 | 20 |
| Farm insured (1=yes) | 0.03 | 0.2 | 0 | 1 |
| Willing to insure farm (1=yes) | 0.53 | 0.5 | 0 | 1 |
| Insurance premium (GHS/acre) | 21.9 | 6.5 | 1 | 30 |
| Contract farming (1=yes) | 0.17 | 0.4 | 0 | 1 |
| Willingness to do contract farming (1=yes) | 0.54 | 0.5 | 0 | 1 |
| Access to credit (1=yes) | 0.14 | 0.4 | 0 | 1 |
| Credit amount (GHS) | 1,087.6 | 1397.5 | 30 | 8,000 |

## 4.2 Sources of Farmland

The sources of farmland are important for farm decisions about input use and commercialization of produce. Secured land tenure implies that farmers can expect to recoup investments made on their farms. Three major sources of land are used in crop farming. From the survey, some farmers cultivated lands under two or three tenure systems; therefore, this multiple response was considered, as shown in Figure 2. The results show that most of the farmers used their own farmlands, while the lowest percentage of farmers used rented farmlands. About 59% of the sampled households owned land, while 42% and 19% of the sampled farmers used family land and rented land, respectively, for agricultural production. Own farmland includes land inherited from parents, land that was personally bought, or family land that was formally distributed or given to the farmer. For family land, the land is held in trust by the household heads and individual members can only use portions of the land upon request from the heads. A more practiced system under rented land is sharecropping, a practice in which landowners provide their land to farmers and share in the harvest.

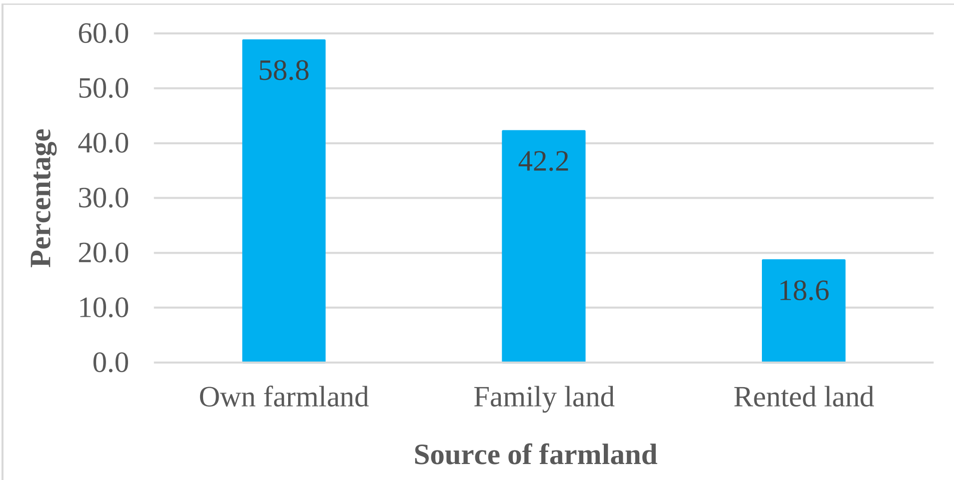



*Figure 2. Percentage distribution of the sources of farmland*

## 4.3 Distribution of Farmers Cultivating Various Crops

Figure 3 shows the percentage distribution of the crops cultivated by the farmers. In the 2019 cropping season, 97.4% of the interviewed farmers cultivated maize. Generally, maize is the number one staple crop cultivated by almost every farm household and consumed by almost every household in Ghana. The second major crop cultivated among the sampled farmers was groundnut, followed by soybean and rice.

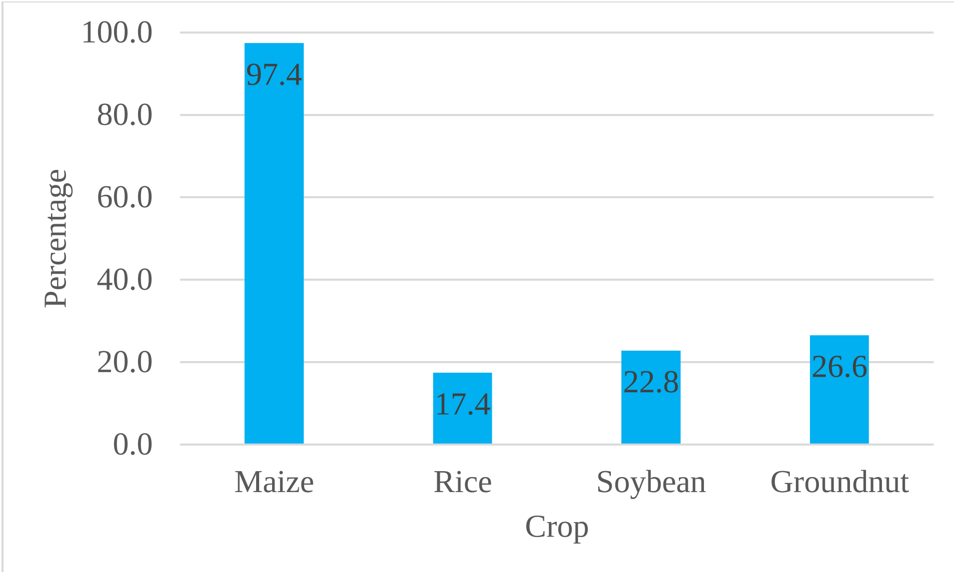



***Figure 3. Percentage of households cultivating various crops***

## 4.4 Allocation of Farm Inputs in Crop Production

Table 5 shows the farm inputs allocated to the different crops under study. An average of 2.2 ha of land per household was allocated to maize production, although about 73% of the maize farmers had farms of less than 2 ha. Scheiterle et al. (2019) shows that the average area cultivated under maize in the Guinea Savannah zone is 1.9 ha. On average, about four family laborers were used per hectare of maize. These family members were used for almost all farm activities throughout the production season. Also, about seven hired individuals were used on a 1 ha farm for different activities. The rates of local and improved seed used for maize production were 31.3 kg/ha and 30.0 kg/ha, respectively. These are higher than the 25 kg/ha recommended seed rate for northern Ghana (IFDC, 2015). The quantity of herbicide used per hectare was approximately 7 liters.

About 1.4 ha of land was cultivated to rice, with about 81% of the farms being less than 2 ha. On average, seven family laborers were used in performing almost every activity on a 1 ha rice farm. For hired labor, an average of nine persons were used for specific activities within the production season. The local and improved seed rates per hectare were 49.3 kg/ha and 49.4 kg/ha, respectively. These are higher than the recommended sowing rates of 40 kg/ha for broadcasting and 35 kg/ha for drilling (IFDC, 2015). While some farmers used only one type of seed (local or improved), others used both. The quantity of herbicide used in the production of rice averaged 7 liters/ha.

The average plot size of soybean was 1.5 ha, with an average family and hired labor of six and 10 people per hectare, respectively. The sampled farmers used about 27.59 kg/ha of local soybean seed, 21.2 kg/ha of improved soybean seed, and 4 liters/ha of herbicide. These rates are far lower than the recommended 50-60 kg/ha seeding rate (IFDC, 2015).

Comparatively, the results suggest that farmers allocated more land to maize cultivation, while more labor was used on soybean and rice plots. The relatively large area allocated to maize, as opposed to the other crops, is consistent with the national cropland allocation. The use of herbicides was also high for rice and maize farmers.

*Table 5. Descriptive statistics of farm inputs used in crop cultivation*

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| ***Maize*** | | | | |
| Cultivated area (ha) | 2.2 | 2.5 | 0.2 | 20 |
| Family labor (number/ha) | 4 | 4.0 | 1 | 50 |
| Hired labor (number/ha) | 7 | 7.8 | 1 | 75 |
| Local seed (kg/ha) | 31.3 | 99.8 | 0.5 | 837.5 |
| Improved seed (kg/ha) | 30.0 | 76.6 | 1.1 | 720 |
| Herbicide (liters/ha) | 6.6 | 27.2 | 1 | 750 |
| ***Rice*** | | | | |
| Cultivated area (ha) | 1.4 | 1.8 | 0.2 | 20 |
| Family labor (number/ha) | 7 | 7.5 | 1 | 50 |
| Hired labor (number/ha) | 9 | 8.5 | 1 | 50 |
| Local seed (kg/ha) | 49.3 | 86.9 | 1 | 500 |
| Improved seed (kg/ha) | 49.4 | 85.9 | 0.4 | 500 |
| Herbicide (liters/ha) | 6.6 | 11.3 | 1 | 120 |
| ***Soybean*** | | | | |
| Cultivated area (ha) | 1.5 | 1.2 | 0.2 | 10 |
| Family labor (number/ha) | 6 | 6.1 | 1 | 60 |
| Hired labor (number/ha) | 10 | 12.2 | 1 | 88 |
| Local seed (kg/ha) | 27.5 | 67.5 | 0.4 | 750 |
| Improved seed (kg/ha) | 21.2 | 29.8 | 3.6 | 125 |
| Herbicide (liters/ha) | 4.3 | 3.270 | 1 | 12 |

## 4.5 Farmers' Perception of the Soil Fertility Status of Farmlands

Table 6 shows the farmers' description of the fertility status of their farmlands. Very fertile means a farmer can produce maximum yield on the soil without external fertilizer; Fertile means a farmer can produce without fertilizer but obtains less than the expected yield. Less fertile means a farmer cannot produce the crop without using fertilizer. On average, the majority of the farmers (54.9%) described their crop soils as fertile. Relative to maize and rice, more farmers who cultivated groundnut and soybean described their soils as very fertile. This is because, as legumes, these crops can fix atmospheric nitrogen to the soils. Only 10.1% of the farmers who cultivated maize described their farmlands as very fertile, while over one-fourth considered their soils less fertile. The implication from the results is that, from the farmers' perspective, about one in every five farmers must necessarily apply fertilizer to their farmlands in order to obtain the expected yields. The high proportion of farmers who perceived their soils to be fertile or very fertile implies that there are factors other than fertilizer that the farmers considered necessary to obtain the expected yield.

*Table 6. Frequency distribution of farmers' perceptions on soil fertility status*

| Crop | Very Fertile | | Fertile | | Less Fertile | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Freq. | % | Freq. | % | Freq. | % | Freq. | % |
| Maize | 143 | 10.1 | 844 | 59.7 | 426 | 30.1 | 1,413 | 100.0 |
| Rice | 31 | 12.3 | 168 | 66.4 | 54 | 21.3 | 253 | 100.0 |
| Soybean | 70 | 21.1 | 160 | 48.3 | 101 | 30.5 | 331 | 100.0 |
| Groundnut | 157 | 40.8 | 173 | 44.9 | 55 | 14.3 | 385 | 100.0 |
| Pooled | 100 | 21.1 | 336 | 54.9 | 159 | 24.1 | 596 | 100.0 |

## 4.6 Adoption of Integrated Agricultural Practices

Table 7 describes farmers' adoption of integrated production practices across the different crops. Aside from low use of pesticide/insecticides (20%) for groundnut, the data shows that 51% of the sampled farmers used pesticide/insecticide on maize and rice while 43% used pesticide/insecticide on soybean. The adoption of minimum tillage was around 50%, as over 50% of farmers engaged in the use of tractor for plowing their farmlands. Cover cropping was used by 24% of the maize farmers, while less than 18% of the other crop farmers adopted this practice. Generally, as many as 13% of the rice famers practiced irrigation farming, while less than 10% did so for maize, soybean, and groundnut.

Mulching was done by 57% of the soybean farmers, while 26% and 24% of rice and maize farmers, respectively, practiced this. Bunding is a water management practice that is employed by 29% of the rice farmers to conserve water. The use of bunding is low for the other crops since these crops have a low survival rate under flooding. Considering that the rains have become erratic, bunding is a good option for water management on the farms. Raes et al. (2007) estimated that the use of bunding leads to an increase in the yield of rice. Mixed cropping and crop rotation were mostly employed on maize, soybean, and groundnut plots. About 24% and 21% of the soybean and groundnut farmers, respectively, integrated crops with livestock, while this practice was much lower for maize and rice farmers. Of the maize farmers, 11% used organic fertilizers (manure) compared to 5% of rice farmers. The farmers obtained organic manure from their livestock farms. The use of inorganic fertilizer will be discussed in the next chapter.

The data suggest that the adoption of integrated agricultural practices is modest among the farmers. A higher rate of adoption of some of these practices could help to close the large yield gaps that have been reported over the years by MoFA. Adoption of these practices could also ensure that the use of fertilizer generates the desired and expected yield results. Nonetheless, stimulating adoption of production practices should only be pursued when the quantitative impact on yield and farm income is known.

*Table 7. Mean statistics of adoption of integrated production practices*

| | Maize | | Rice | | Soybean | | Groundnut | |
|---|---|---|---|---|---|---|---|---|
| **Variable** | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** |
| Pesticides/insecticides | 0.51 | 0.50 | 0.53 | 0.51 | 0.43 | 0.51 | 0.21 | 0.41 |
| Zero/minimum tillage | 0.49 | 0.50 | 0.49 | 0.50 | 0.33 | 0.47 | 0.20 | 0.42 |
| Cover cropping | 0.24 | 0.43 | 0.11 | 0.31 | 0.10 | 0.30 | 0.17 | 0.38 |
| Irrigation | 0.06 | 0.23 | 0.13 | 0.34 | 0.05 | 0.22 | 0.04 | 0.20 |
| Mulching | 0.24 | 0.43 | 0.26 | 0.45 | 0.57 | 0.51 | 0.13 | 0.34 |
| Bunding | 0.10 | 0.30 | 0.29 | 0.46 | 0.05 | 0.22 | 0.13 | 0.34 |
| Mixed cropping | 0.42 | 0.49 | 0.08 | 0.27 | 0.14 | 0.36 | 0.58 | 0.50 |
| Crop rotation | 0.55 | 0.50 | 0.13 | 0.34 | 0.71 | 0.46 | 0.75 | 0.44 |
| Crop-livestock integration | 0.16 | 0.36 | 0.13 | 0.34 | 0.24 | 0.44 | 0.21 | 0.41 |
| Organic fertilizer | 0.11 | 0.32 | 0.05 | 0.23 | 0.10 | 0.30 | 0.08 | 0.28 |

## 4.7 Farm Output and Distribution

The farm output, utilization, and marketing of the various crops are reported in Table 8. Comparatively, the highest yield was reported for soybean, followed by groundnut, rice, and maize. On average, a soybean or groundnut farmer produced about 2.3 mt/ha while a maize farmer produced about 1.4 mt/ha. Thus, the average maize farmer produced 3.2 mt from the entire land area cultivated, while the rice and soybean farmers produced 3 mt and 2.3 mt, respectively. Except for soybean, the observed yields were lower than the average yield and achievable yields of these crops in Ghana. The achievable yields for maize, rice, and soybean are 5.5 mt/ha, 6 mt/ha and 3 mt/ha, respectively, and the average yields are 1.99 mt/ha, 2.9 mt/ha, and 1.65 mt/ha, respectively (MoFA, 2017). Under the current farmer practice, MacCarthy et al. (2018) reports that the average maize yield in the Tamale and Bolgatanga is about 1.8 mt/ha and 1.1 mt/ha, respectively. This regional difference in the yields is presented in Chapter 9 of this report.

From the data, not all farmers sell portions of their produce. For instance, about 24% of the maize farmers did not sell any of their maize output. However, Table 8 shows that, for all crops, farmers who sell portions of their produce generally sell a higher share than they use for domestic consumption. This may suggest that farmers are gradually commercializing their production. Farmers continue to save a portion of their seeds. Post-harvest losses were between 0.009 and 0.02 mt/ha, depending on the crop.

*Table 8. Mean statistics crop yield and post-harvest management*

| Variable (kg/ha) | Maize | | Rice | | Soybean | | Groundnut | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| Yield | 1,441.7 | 758.8 | 2,125.9 | 1,123.0 | 1,536.2 | 746.6 | 2,326.7 | 869.4 |
| Marketed | 1,642.1 | 561.9 | 1,680.4 | 1,167.7 | 1,402.2 | 1,273.1 | 1,933.0 | 1,056.4 |
| Consumed | 1,091.0 | 603.7 | 770.1 | 642.5 | 450.1 | 512.6 | 407.1 | 461.4 |
| Post-harvest loss | 148.5 | 343.1 | 120.8 | 388.2 | 88.9 | 283.5 | 93.5 | 287.1 |
| Saved seed | 444.1 | 251.4 | 399.8 | 393.2 | 264.7 | 305.6 | 449.9 | 364.5 |

*Note: The sum of means for the output distribution does not add up to production, since the samples are different based on the distribution. Yields are disaggregated at the regional level and by fertilizer type in Chapter 9.*

## 4.8 Market Access and Commercialization

### 4.8.1 *Purpose of Crop Production*

Figure 4 shows the reasons for the cultivation of each crop. The results show that, for all crops, the primary reason for cultivation of most of the farmers was sales. This supports the results in Table 8, which show more crop outputs were sold than consumed. For soybean, all farmers cultivated it mainly for sales. About 89% of groundnut producers also produced mainly for sales but only 49% of maize producers did so. The results reflect the fact that maize and rice are the first and second major staple crops, respectively, of the country, hence the relatively high percentage of farmers who cultivate them for home consumption. Nonetheless, more could be done to encourage maize farmers to increase maize production for commercial purposes and/or aim at producing for the market. There were a few farmers who are either not sure or indifferent as to whether they were producing these crops mainly for domestic consumption or for sales.

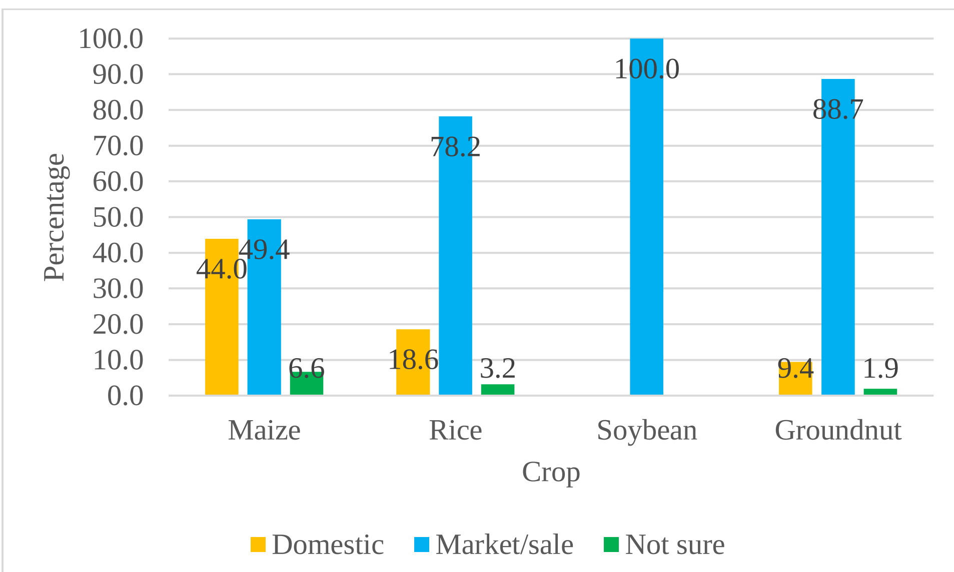



***Figure 4. Percentage distribution of the reasons for crop production***

### 4.8.2 *Sources of Market for Crop Produce*

Figure 5 shows the sales points for the four crops together, and the specific sales point for each crop is given in Table 9. Three sales points were identified among the farmers: farm gate (selling on the farm), home, and market. Figure 5 shows that most farmers (60.1%) sold their farm produce to buyers at their homes, while 32.3% and 2.1% sold their produce solely at the market and farm gate, respectively. About 10.4% of the remaining farmers sold their produce at two or more of the sales points.

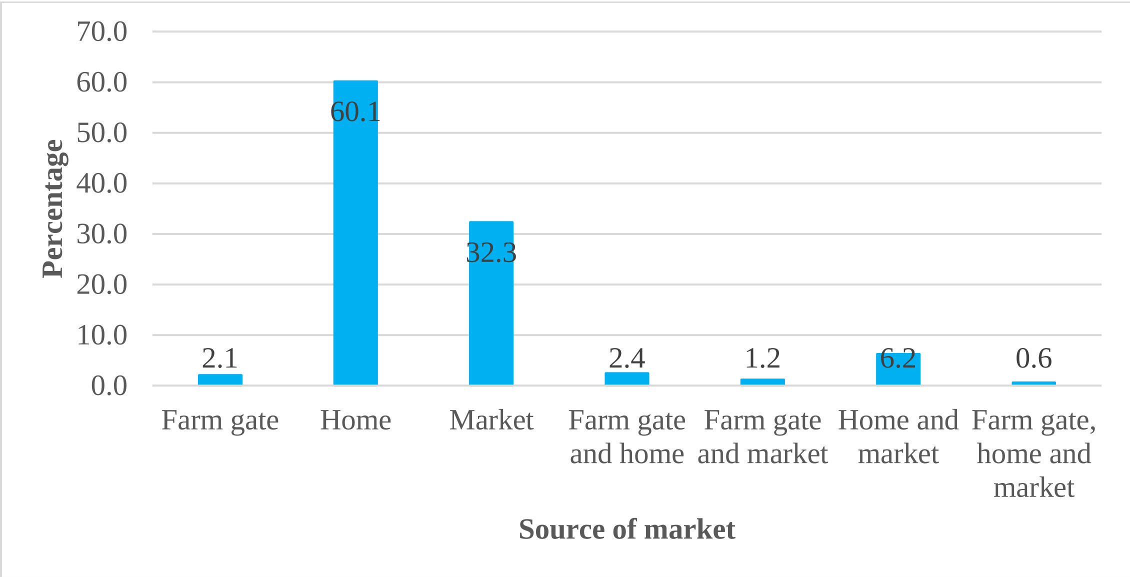



***Figure 5. Percentage distribution of the sources of market for all four crops***

### 4.8.3 *Distance and Farmer Perception of Market Accessibility*

The distance to the markets in which the farmers sold each of their crop produce is shown in Table 9. From the result, the farmers traveled a longer distance to sell maize than the other crops. On average, rice and groundnut producers traveled the same distance (perhaps to the same markets) to sell their produce. Consistent with Table 8, the results show that farmers who sold soybean in the market traveled a very short distance (mostly to the local community markets). Although some farmers traveled to distant markets in Accra, the data show that only about 6% of the farmers traveled to a market that was more than 10 kilometers (km) away from their home.

Figure 6 shows the respondents' perception on the ease of getting their farm produce to a market center. This assessment was made giving consideration to the availability of vehicles for transporting the goods, the nature of the roads, and the nearness to a market. The results show that most of the maize and rice producers indicated an average ease of getting to a market, while the highest percentage (41.5%) of the groundnut producers revealed a high ease of getting their outputs to the market. Ease of getting to a market is crucial for commercialization of farms. Where markets may not exist or where it is difficult to get to the market, farmers may resort to subsistence production objectives, and this may affect their fertilizer consumption decisions.

*Table 9. Descriptive statistics of distance to crop output market*

| Crop | Mean (km) | Max | Std. Dev. |
|---|---|---|---|
| Maize | 8.4 | 480 | 46.7 |
| Rice | 2.3 | 300 | 19.2 |
| Soybean | 0.5 | 12 | 1.8 |
| Groundnut | 4.1 | 300 | 23.6 |

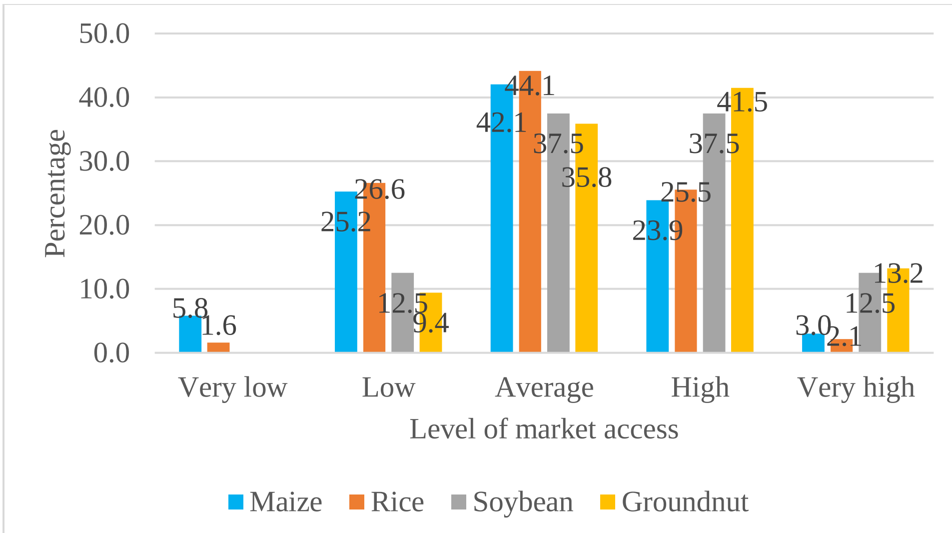



***Figure 6. Percentage distribution of farmers' perception of accessibility to crop output markets***

### 4.8.4 *Perception of Output Prices*

Figure 7 shows the farmers' opinion on the price level of their crop produce, which revealed that most of the producers of all crops see the prices for their produce to be low. For instance, 44.2% and 39.4% of maize and rice producers, respectively, indicated a low price for their produce. The results also show that the percentage of farmers who indicated high to very high prices for legume crops (groundnut and soybean) is relatively higher than those for the cereal crops (maize and rice).

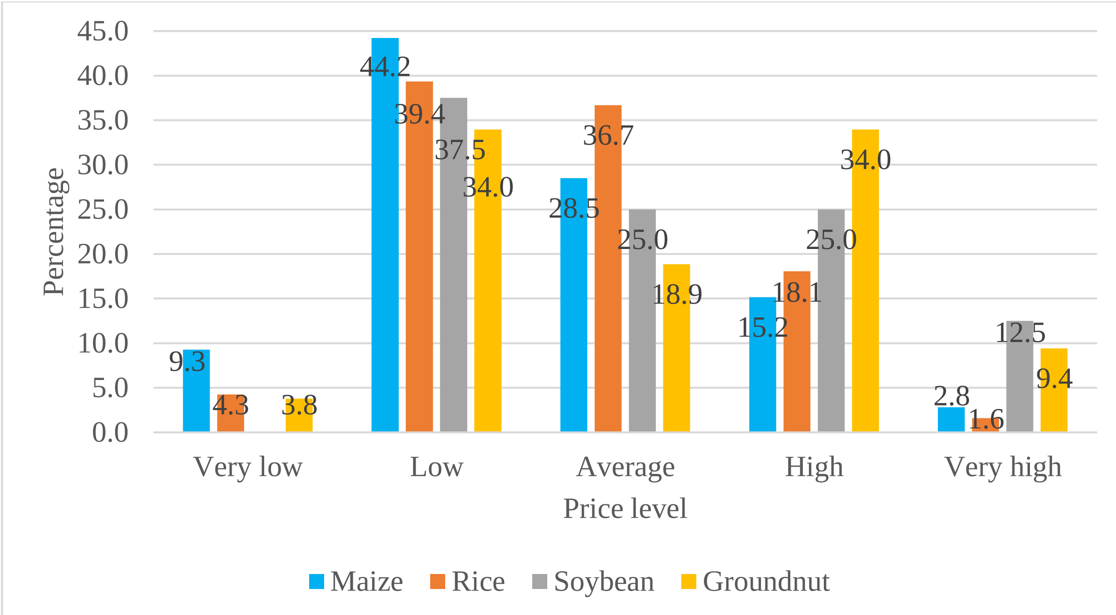



***Figure 7.*** ***Percentage distribution of farmers' perception on output price***

# CHAPTER 5: FERTILIZER USE IN CROP PRODUCTION

## 5.1 Distribution of Farmers Using Fertilizer in Crop Production

The data in Table 10 show that, of the 1,450 farmers interviewed, 1,168 (80.5%) used at least one form of fertilizer. Among these fertilizer users, nearly half (48.6%) purchased fertilizer only at commercial prices.

Figure 8 shows the distribution of farmers who used fertilizer by the price type and access to input shop. This shows that, among farmers who have input shop(s) in their communities, the majority purchased fertilizer at commercial prices. Conversely, the majority of farmers with no input shop in their communities purchased fertilizer at subsidized prices. This is because the subsidized fertilizers are often supplied by retail shops whose wholesale agents have successfully bidded for the subsidized fertilizers. Often, these retail shops are located in the district capitals, and therefore, most of the community input shops do not selling the subsidized fertilizers. Also, farmers may be willing to purchase fertilizer at commercial prices if the fertilizer is located in their community because it eliminates other challenges, such as transportation access and cost.

*Table 10. Percentage distribution of fertilizer use by farmers and price type*

| Response | Frequency | Percentage |
|---|---|---|
| ***Use of fertilizer*** | | |
| Users | 1,168 | 80.5 |
| Non-users | 282 | 19.5 |
| ***Fertilizer price type*** | | |
| Subsidized | 600 | 51.4 |
| Commercial | 568 | 48.6 |

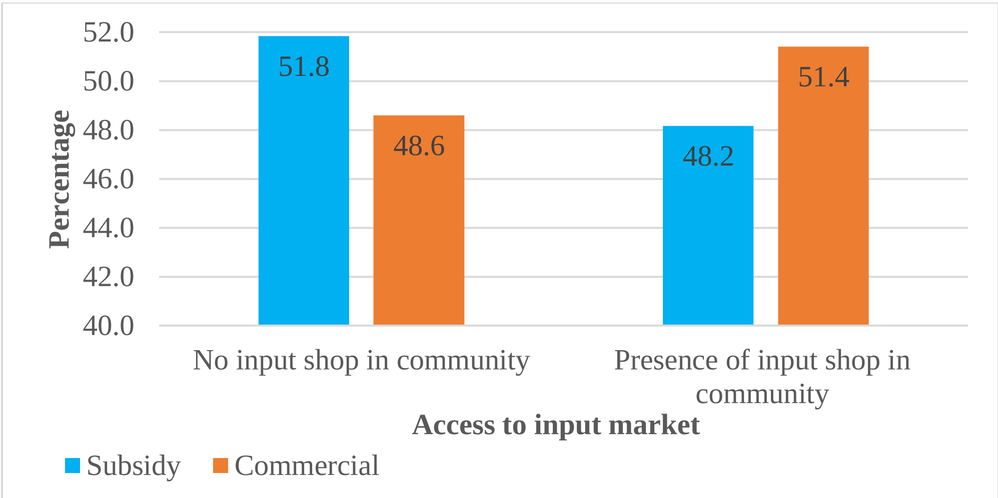



*Figure 8. Percentage of fertilizer by price type purchased by farmers in relation to their access to an input shop*

## 5.2 4R Nutrient Stewardship

The 4R principles of nutrient stewardship are a tool to help achieve the goals for cropping systems, such as improving farm income and profitability, protecting the environment, and improving the sustainability of production systems. These principles include the right source, right time, right place, and right rate in the use of fertilizer. This involves the application of the appropriate fertilizer (right source) at the appropriate stage of the crop (right time) using a recommended quantity (right rate) placed at the root areas (right place) where the crops can make optimal use of the nutrients.

Table 11 shows that nearly two-thirds of the farmers indicated they use the right source of fertilizer, while over two-thirds indicated they applied fertilizers at the right time. About four in every five farmers applied fertilizer by a method other than broadcasting, thus in the right place. Less than half of the farmers indicated that they applied fertilizer at the recommended rate. Farmers who did not practice these principles indicated their reasons. Generally, inadequate capital was outlined as the dominant reason for not applying the recommended rate of fertilizer, while lack of labor, cost, and convenience were the main factors for broadcasting, rather than placement, of fertilizer. Aside from these perceptions on fertilizer use, the observed quantities used were analyzed and this is discussed in Section 5.2 and Chapter 9. These show that most of the farmers used less than the recommended application rates.

*Table 11. Frequency distribution of compliance with 4R of nutrient stewardship*

| Response | Frequency | Percentage |
|---|---|---|
| **Use recommended fertilizer type (right source)** | | |
| Yes | 852 | 72.9 |
| No | 316 | 27.1 |
| **Reason for non-use of recommended fertilizer type** | | |
| Inadequate funds/capital | 219 | 69.3 |
| Unavailability of fertilizer for each crop | 38 | 12.0 |
| Low/lack of knowledge | 53 | 16.8 |
| Not needed | 6 | 1.9 |
| **Apply fertilizer at right time** | | |
| Yes | 903 | 77.3 |
| No | 265 | 22.7 |
| **Non-application at right time (reasons)** | | |
| Lack of fertilizer in input stores | 50 | 19.5 |
| Lack of fund at the right time | 153 | 59.8 |
| Bad weather | 20 | 7.8 |
| Lack of labor at the right time | 5 | 2.0 |
| Lack of capital at the right time | 37 | 14.5 |
| **Broadcasting of fertilizer (right place)** | | |
| Yes | 228 | 19.5 |
| No | 940 | 80.5 |

| Response | Frequency | Percentage |
|---|---|---|
| **Reason for broadcasting** | | |
| Lack of labor for other methods | 56 | 24.6 |
| Unaware of other methods | 8 | 3.5 |
| Aware of other methods but lack knowledge | 11 | 4.8 |
| Less expensive to broadcast than other methods | 56 | 24.6 |
| Convenience/easy | 73 | 32.0 |
| No response | 24 | 10.5 |
| **Apply fertilizer at recommended rate (right rate)** | | |
| No | 619 | 53.0 |
| Yes | 549 | 47.0 |
| **Reason for non-use of recommended rate** | | |
| Inadequate fund/capital | 427 | 69.0 |
| Unavailability of fertilizer | 33 | 5.3 |
| Low/lack of knowledge | 82 | 13.2 |
| Not needed | 5 | 0.8 |
| No response | 72 | 11.6 |

## 5.3 Types of Fertilizer Used in Crop Farming and Average Price

Figure 9 shows the percentage distribution of farmers who applied each of the studied fertilizer types during the 2019 cropping season. Overall, the number of farmers using each fertilizer type was very low. One-third of the farmers used NPK 15-15-15, while about one in every five farmers used urea, AS, or NPK 15-20-20+0.7Zn. The results show that the use of blended fertilizer was very low among farmers. This not surprising given that NPK 15-15-15 along with AS or urea has been promoted over the years to farmers in Ghana. Recent specialized combinations of NPK with trace minerals, such as zinc, magnesium, and calcium, are unpopular or rarely used. NPK+Zn has seen considerable use because it was introduced and promoted by GoG through its PFJ program in 2019. Fertilizers under the PFJ subsidy program included NPK 15-15-15, NPK 15-20-20+0.7Zn, NPK 20-10-10+3S+2MgO, NPK 25-10-10, NPK 23-10-5+4MgO+2Zn, NPK 12-30-17+0.4Zn, NPK 17-10-10, and urea.

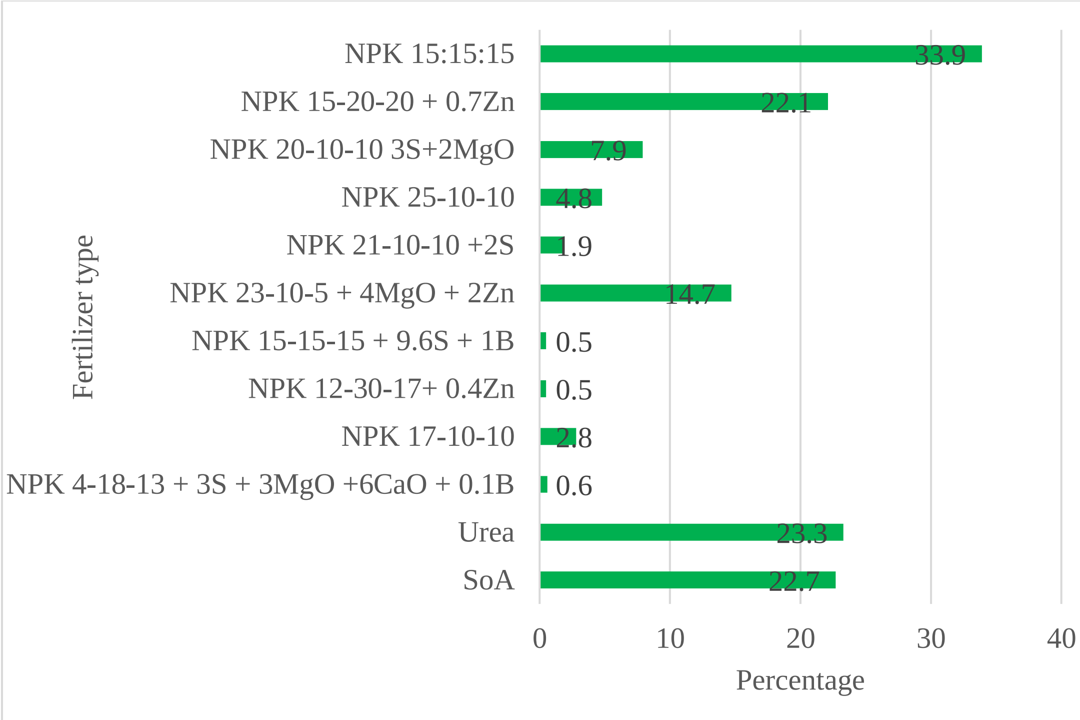



***Figure 9. Percentage distribution of the types of fertilizers applied by farmers***

Figure 10 shows the percentage distribution of farmers using multiple fertilizers. Only 19.5% of the farmers did not use any of the fertilizer types examined in this study. Thhe highest proportion of the farmers (38.8%) used only one type of fertilizer, while 31.8% of the farmers used two fertilizer types. This is lower than the result of Ragasa and Chapoto (2017), in which 87% of the farmers in northern Ghana used fertilizer. MoFA's recommendation under the PFJ program is that farmers use two different fertilizers – NKP 15-20-20+0.7Zn and urea – on their cereal farms (MoFA, 2019). Juxtaposing this with Figure 9 suggests that about four in every 10 farmers did not comply with the recommended rates. This is contrary to the response of most of the farmers, who indicated applying the right source of fertilizer (Table 12).

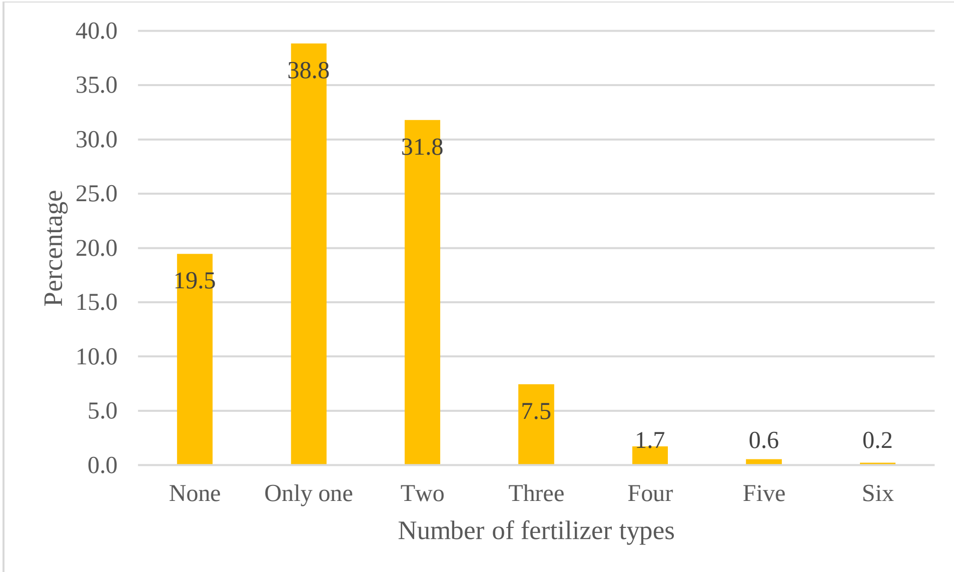



***Figure 10. Percentage distribution of the number of fertilizer types used by farmers***

Figure 11 shows the average prices paid by the farmers either at subsidized or commercial prices. Overall, the average price paid for subsidized fertilizer ranged between 49 and 70 GHS/25 kg, while commercial prices ranged between 70 and 118 GHS/25 kg. Some farmers indicated paying for fertilizers that were not captured under the PFJ program. Under the PFJ program, farmers were expected to pay 75 GHS/50 kg for all NPK fertilizer types and 70 GHS/50 kg for urea (MoFA, 2019).

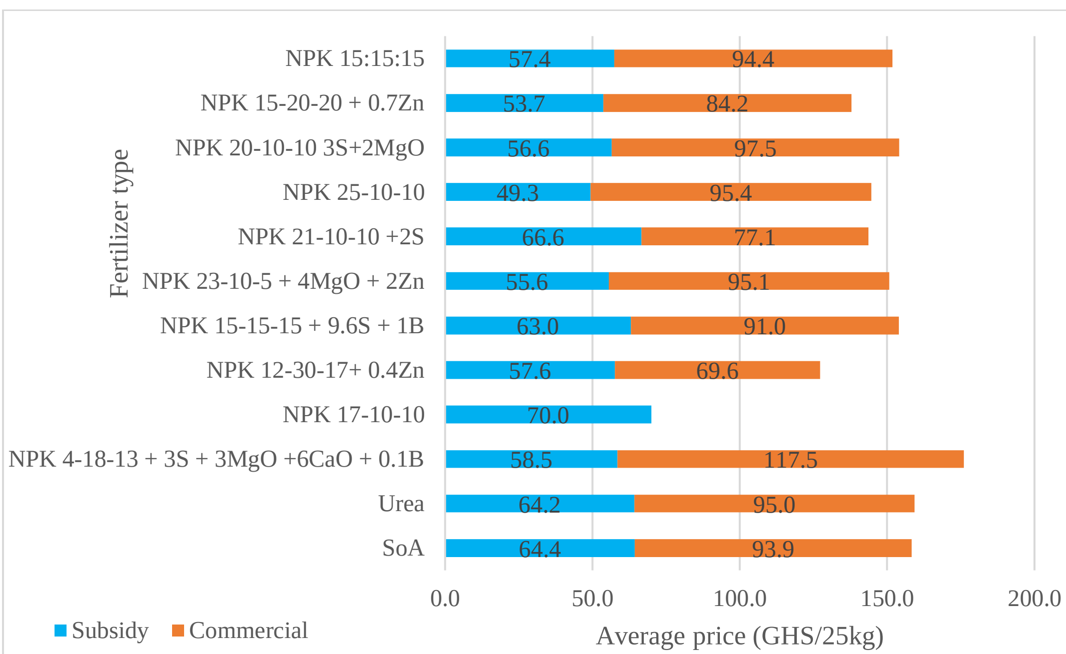



***Figure 11. Average price (GHS/25 kg) of different fertilizer types***

## 5.4 Distribution of Fertilizer Use by Crop

Tables 12-14 show the distribution of farmers who used the various fertilizer types and the quantities at both commercial and subsidized prices in the cultivation of maize, rice, and soybean. The frequency of farmers buying each fertilizer at either the subsidized or commercial price or both is shown in parentheses. Although some farmers misrepresented some fertilizers as subsidized, this survey did not establish whether some fertilizers outside the PFJ program were sold at the subsidized rate as a business strategy; therefore, the responses of the farmers are treated as though this was the case.

NPK 15-15-15 was the major fertilizer used by about 34% of the farmers but was the second largest in terms of quantity applied per hectare (Table 12). Specifically, while farmers who used subsidized NPK 15-15-15 applied 336.4 kg/ha, those who used commercial NPK 15-15-15 applied 221.8 kg/ha. Some farmers used both commercial and subsidized NPK 15-15-15, and these farmers applied only 144.8 kg/ha. Therefore, the subsidy on NPK 15-15-15 appears to enhance its application rate in maize farms.

Although applied by only 6.7% of the maize farmers, NPK 20-10-10+3S+2MgO was applied in a relatively larger quantity per hectare than the other fertilizers. Generally, the farmers applied an average of 364.8 kg/ha on a maize farm. About one in every five maize farmers also used NPK 15-20-20+0.7Zn, urea, and AS fertilizers. However, the quantity applied of these fertilizers was relatively lower than other fertilizers (NPK 21-10-10+2S and NPK 4-18-13+3S+3MgO+6CaO +0.1B) that were used by only few farmers.

Maize farmers who indicated buying NPK 15-15-15, NPK 21-10-10+2S, NPK 23-10-5+4MgO+2Zn, NPK 4-18-13+3S+3MgO+6CaO+0.1B, and AS at subsidized prices applied a higher quantity per hectare than those who purchased these fertilizers at commercial prices. On the other hand, maize farmers who purchased NPK 15-20-20+0.7Zn, NPK 20-10-10 3S+2MgO, NPK 25-10-10, NPK 15-15-15+9.6S+1B, NPK 12-30-17+0.4Zn, and urea at commercial prices applied a higher quantity per hectare than those who purchased the fertilizers at subsidized prices.

*Table 12. Frequency distribution of the types and quantities of fertilizer used in maize production*

| Fertilizer Type | Users | | Price type: Subsidy (kg/ha) | | Price type: Commercial (kg/ha) | | Price type: *Both (kg/ha) | | Total (kg/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Freq. | % | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| NPK 15-15-15 | 463 | 32.8 | 336.4 (292) | 235.7 | 221.8 (167) | 498.1 | 144.8 (4) | 86.9 | 293.4 | 189.5 |
| NPK 15-20-20+0.7Zn | 299 | 21.2 | 187.4 (209) | 155.7 | 197.4 (89) | 196.0 | 500.0 (1) | - | 191.4 | 169.1 |
| NPK 20-10-10+ 3S+2MgO | 94 | 6.7 | 238.2 (65) | 253.1 | 200.5 (27) | 228.7 | 143.8 (2) | 61.9 | 225.6 | 61.9 |
| NPK 25-10-10 | 66 | 4.7 | 185.9 (49) | 123.2 | 197.1 (17) | 108.7 | - | | 188.8 | 118.9 |
| NPK 21-10-10+2S | 30 | 2.1 | 251.0 (18) | 181.3 | 197.2 (11) | 154.4 | 375.0 (1) | - | 235.4 | 169.9 |
| NPK 23-10-5+4MgO +2Zn | 208 | 14.7 | 161.4 (140) | 119.5 | 157.1 (66) | 90.3 | 468.8 (2) | 221 | 163.0 | 115.3 |
| NPK 15-15-15+9.6S +1B | 8 | 0.6 | 43.2 (2) | 56.7 | 151.6 (6) | 105.8 | - | - | 124.5 | 104.8 |
| NPK 12-30-17+0.4Zn | 39 | 2.8 | 129.6 (27) | 108.6 | 157.7 (12) | 195.6 | - | - | 138.3 | 139 |
| NPK 17-10-10 | 1 | 0.1 | 125.0 (1) | - | - | - | - | - | 125.0 | - |
| NPK 4-18-13+3S +3MgO+6CaO+0.1B | 7 | 0.5 | 229.2 (2) | 29.5 | 216.7 (5) | 156.3 | - | - | 220.2 | 128.3 |
| Urea | 296 | 20.9 | 104.0 (171) | 67.0 | 127.2 (121) | 94.8 | 103.2 (4) | 64.3 | 113.5 | 80.1 |
| AS | 318 | 22.5 | 204.2 (76) | 120.3 | 124.4 (242) | 156.8 | | | 143.5 | 134.8 |

*Note: Total number of maize farmers is 1,413. The reported figures are from multiple responses; therefore, the frequencies (percentages) do not add up to 1,413 (100%). Total number of farmers using a particular fertilizer under each price type is in parentheses.*

*[*]Both means farmers who bought different quantities of the same fertilizer at the subsidized price and commercial price.*

Table 13 shows the fertilizer use among rice farmers. The data show that about 79% of the rice farmers used any type of fertilizer. It is evident that, although only about 26% of the rice farmers used urea, it represents the most used fertilizer by the rice farmers. However, in terms of quantity applied per hectare, NPK 21-10-10+2S and NPK 25-10-10 were largely used at rates of 312.5 kg/ha and 306.25 kg/ha, respectively. Except for urea, the other fertilizer types purchased at commercial prices were used in relatively larger quantities in rice cultivation than fertilizers obtained at subsidized prices. Data show that farmers who purchased fertilizers at commercial prices had significantly higher farm revenues than those who used subsidized fertilizers. This may suggest that the former farmers are more market oriented than the latter farmers.

*Table 13. Frequency distribution of the types and quantities of fertilizer used in rice production*

| | | | Price Type | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Users** | | **Subsidy (kg/ha)** | | **Commercial (kg/ha)** | | **Total (kg/ha)** | |
| **Fertilizer** | **Freq.** | **%** | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** |
| NPK 15-15-15 | 48 | 19.0 | 170.0 (35) | 122.1 | 259 (13) | 258.1 | 194.1 | 171.5 |
| NPK 15-20-20+0.7Zn | 27 | 10.7 | 177.9 (13) | 97.6 | 264.9 (14) | 267.6 | 223.0 | 205.3 |
| NPK 20-10-10+3S+2MgO | 5 | 2.0 | 125.0 (2) | 0.0 | 218.8 (3) | 162.4 | 181.3 | 125.8 |
| NPK 25-10-10 | 5 | 2.0 | 239.6 (3) | 118.3 | 406.3 (2) | 44.2 | 306.3 | 125.8 |
| NPK 21-10-10+2S | 2 | 0.8 | | | 312.5 (1) | | 312.5 | |
| NPK 23-10-5+4MgO +2Zn | 16 | 6.3 | 146.2 (11) | 75.1 | 325.8 (5) | 268.8 | 202.3 | 174.4 |
| NPK 15-15-15 + 9.6S+1B | 3 | 1.2 | | | 250.0 (3) | 125.0 | | |
| NPK 12-30-17+0.4Zn | 3 | 1.2 | 93.8 (2) | 44.2 | 312.5 (1) | . | 166.7 | 130.1 |
| NPK 17-10-10 | 1 | 0.4 | | | | | | |
| NPK 4-18-13+3S+3MgO +6CaO+0.1B | 2 | 0.8 | | | 187.5 (2) | | 187.5 | |
| Urea | 65 | 25.7 | 212.4 (32) | 536.3 | 154.7 (33) | 114.8 | 183.1 | 383.1 |
| AS | 22 | 8.7 | 121.9 (9) | 106.7 | 178.5 (13) | 140.8 | 155.4 | 128.4 |

*Note: Total number of rice farmers is 253. Total number of farmers using a particular fertilizer under each price type are in parentheses.*

Table 14 shows the fertilizers used by soybean farmers. The fertilizer used by the highest proportion of soybean farmers was NPK 15-20-20+0.7Zn. The use of AS, NPK 15-15-15, NPK 23-10-5+4MgO+2Zn, and urea was also considerably high. The data show that farmers who purchased fertilizers at commercial prices used more of most of the fertilizers.

*Table 14. Frequency distribution of the types and quantities of fertilizer used in soybean production*

| Fertilizer | Users | | Price type | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Subsidy (kg/ha) | | Commercial (kg/ha) | | Total (kg/ha) | |
| | Freq. | % | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| NPK 15-15-15 | 73 | 22.2 | 193.3 (41) | 134.1 | 220.8 (32) | 173.1 | 199.3 | 142.7 |
| NPK 15-20-20+0.7Zn | 133 | 40.4 | 233.7 (72) | 177.3 | 369.2 (61) | 317.0 | 266.3 | 225.3 |
| NPK 20-10-10+3S+2MgO | 25 | 7.6 | 197.2 (13) | 178.0 | 264.6 (12) | 191.0 | 209.5 | 177.3 |
| NPK 25-10-10 | 11 | 3.3 | 254.5 (4) | 122.6 | 182.3 (7) | 131.1 | 228.2 | 124.5 |
| NPK 21-10-10+2S | 5 | 1.5 | 307.5 (5) | 173.7 | - | - | 307.5 | 173.7 |
| NPK 23-10-5+4MgO+2Zn | 65 | 19.8 | 190.7 (48) | 151.7 | 160.7 (17) | 126.8 | 187.0 | 148.3 |
| Urea | 65 | 19.8 | 106.1 (34) | 87.1 | 155.0 (31) | 134.2 | 124.1 | 108.5 |
| AS | 73 | 22.2 | 105.4 (18) | 48.7 | 158.5 (55) | 301.6 | 144.7 | 261.0 |

*Note: Total number of soybean farmers is 329. Total number of farmers using particular fertilizer under each price type are in parentheses.*

## 5.5 Challenges to Access to and Use of Fertilizer

Seven key challenges that limit fertilizer use were identified and presented to farmers to rank. The Kendall's rank analysis in Table 15 shows the challenges, in order of severity, were lack of credit, limited reach of subsidized fertilizer in adequate quantities, high cost of unsubsidized fertilizer, inadequate extension service support, lack of fertilizer at the right time, and lack of confidence in fertilizer quality. The implication is that, to enhance the use of fertilizer among smallholder farmers, agricultural credit must be provided to the majority of farmers while the availability of subsidized fertilizers is increased.

*Table 15. Kendall's rank of the challenges to access and use of fertilizers*

| Challenge | Mean | Std. Dev. | Rank |
|---|---|---|---|
| Inadequate extension service support | 3.89 | 2.41 | 4th |
| Inadequate farmer skills | 4.21 | 2.02 | 5th |
| Limited reach of subsidized fertilizer in adequate quantities | 3.57 | 1.49 | 2nd |
| Limited credit for small farmers | 3.29 | 1.63 | 1st |
| High cost of unsubsidized fertilizer | 3.71 | 1.71 | 3rd |
| Lack of confidence in fertilizer quality | 4.81 | 1.86 | 7th |
| Lack of fertilizer at the right time | 4.52 | 2.26 | 6th |
| **Test Statistic** | | | |
| Kendall's W | | 0.063 | |
| Chi-Square | | 537.477 | |
| df | | 6 | |
| Asymp. Sig. | | 0.000 | |

### 5.5.1 *Recommendations to the Challenges of Access and Use of Fertilizer*

The sampled farmers provided key recommendations necessary to help address the stated challenges to access to and use of fertilizer. The results are presented in Table 16. To address extension challenges, a high proportion of farmers (47%) indicated that the number of extension officers should be increased. An additional 21.9% of the farmers (perhaps those farmers who received extension services) indicated that the number of contacts with extension officers should be increased. Currently, the extension officer-to-farmer ratio stands at 1:1,850 (MoFA, 2019). About 21% of the farmers called for the creation of localized or community extension offices. This is consistent with the results in Table 3, showing that most of the farmers were located in communities with no extension office. Perhaps this could be better handled using the training of trainers approach, in which key farmers in each community are trained on basic extension services and then provide extension information or services to other farmers. The farmers also suggested that digital or e-extension platforms, such as mobile phones, radio, and other communication channels, should be explored.

Regarding the inadequate supply of subsidized fertilizer, most of the farmers (64%) recommended the supply of subsidized fertilizer be increased. The government should work with input dealers to supply in advance the quantity of inputs required to cultivate arable lands in the country. The second major recommendation for this problem is that the government should remove or reduce bureaucracies in accessing subsidized fertilizers.

The highest percentage of the farmers recommended that credit should be provided in kind. This includes the provisioning of fertilizer and other inputs, such as seeds and herbicides, to the farmers, who then pay for these after harvest. This is a call for contract farming, which most of the farmers are willing to do (see Table 4). The second major appeal is for provisioning credit facilities in the local communities. This may be an issue the private sector and micro savings institutions in the various areas need to explore. However, the concept of Village Savings and Loan Associations (VSLA, 2007) could be an attractive alternative in responding to the need for the establishment of localized credit facilities. Interest rates remain a major drawback in credit requests. Therefore, the farmers recommended a reduction in the interest charges on loans.

To address the lack of confidence in fertilizers, the highest percentage of the farmers (43%) recommended that the farmers must be educated on each fertilizer type, especially the newly introduced ones. The farmers also called for the establishment of field trials on fertilizers in which the farmers would participate and for the government to institute monitoring mechanisms to ensure that the fertilizers supplied under subsidy program (PFJ) are those that are delivered or supplied to the farmers.

The data show that the use of commercial fertilizers is high among farmers. Therefore, according to 44% of the farmers, the government needs to regulate the price of commercial fertilizer such that individual input dealers do not exceed a ceiling price. An additional 39% of the farmers expressed that the prices of the commercial fertilizers must be reduced.

*Table 16. Frequency distribution of the recommendations to the challenges of access and use of fertilizer*

| Recommendation (#) | Frequency | Percentage |
|---|---|---|
| ***Extension services*** | | |
| Increase number of extension officers | 682 | 47.0 |
| Increase number of visits to farmers | 317 | 21.9 |
| Create local extension offices in communities | 300 | 20.7 |
| Improve the quality of extension services | 82 | 5.7 |
| Do not know of any recommendation | 38 | 2.6 |
| No response | 31 | 2.1 |
| Total | 1,450 | 100.0 |
| ***Inadequacy of subsidized fertilizer*** | | |
| Increase supply of subsidized fertilize | 922 | 63.6 |
| Reduce bureaucracies in accessing subsidized fertilizers | 270 | 18.6 |
| Reassess the coupon system (e.g., share coupons in communities) | 113 | 7.8 |
| Remove the coupon system completely | 88 | 6.1 |
| Do not know of any recommendation | 36 | 2.5 |
| No response | 21 | 1.5 |
| Total | 1,450 | 100.0 |
| ***Low access to credit*** | | |
| Remove/minimize collateral requirements | 259 | 17.9 |
| Provide credit in in-kind form | 451 | 31.1 |
| Reduce interest on credit | 307 | 21.2 |
| Provide credit facilities in local communities | 382 | 26.3 |
| Do not know of any recommendation | 30 | 2.1 |
| No response | 21 | 1.5 |
| Total | 1,450 | 100.0 |

| Recommendation (#) | Frequency | Percentage |
|---|---|---|
| ***High cost of commercial fertilizer*** | | |
| Government should regulate commercial prices | 632 | 43.6 |
| Reduce prices | 569 | 39.2 |
| Reduce quantity of subsidized fertilizer supplied | 97 | 6.7 |
| Reduce import and domestic taxes on fertilizers | 112 | 7.7 |
| Do not know of any recommendation | 28 | 1.9 |
| No response | 12 | 0.8 |
| Total | 1,450 | 100.0 |
| ***Lack of confidence in fertilizer quality*** | | |
| Organize field trials on fertilizers | 474 | 32.7 |
| Provide education on various fertilizer types | 617 | 42.6 |
| Monitor fertilizer companies to ensure the fertilizers supplied to farmers have the necessary components | 201 | 13.9 |
| Do not know of any recommendation | 65 | 4.5 |
| No response | 93 | 6.4 |
| Total | 1,450 | 100.0 |
| ***Untimely supply of fertilizer*** | | |
| Increase supply of subsidized fertilizers | 514 | 35.5 |
| Provide localized input/fertilizer shops | 374 | 25.8 |
| Supply fertilizers before start of farming seasons | 483 | 33.3 |
| Do not know of any recommendation | 39 | 2.7 |
| No response | 40 | 2.8 |
| Total | 1,450 | 100.0 |

## 5.6 Socioeconomic Characteristics and Fertilizer Use

### 5.6.1 *Gender and Fertilizer Use*

Table 17 shows the fertilizer use by male and female farmers. Generally, the percentage of male farmers using each fertilizer type was higher than the percentage of females using each fertilizer type. For instance, while the percentage of male users of NPK 15-15-15 per non-users was 55.3%, the percentage of female users per non-users was only 35.4%. Thus, while six out of every 10 male farmers used NPK 15-15-15, , only about four out of every 10 female farmers used this fertilizer. All other fertilizer types, except NPK 25-10-10 and NPK 4-18-13+3S+3MgO+6CaO+0.1B, followed the same trend.

*Table 17. Frequency distribution of gender and fertilizer use*

| Fertilizer Type | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | Users | Non-Users | % of Users per Non-Users | Users | Non-Users | % of Users per Non-Users |
| NPK 15-15-15 | 421 | 761 | 55.3 | 70 | 198 | 35.4 |
| NPK 15-20-20+0.7Zn | 265 | 917 | 28.9 | 56 | 212 | 26.4 |
| NPK 20-10-10+3S+2MgO | 98 | 1,084 | 9.0 | 17 | 251 | 6.8 |
| NPK 25-10-10 | 53 | 1,129 | 4.7 | 17 | 251 | 6.8 |
| NPK 21-10-10+2S | 23 | 1,159 | 2.0 | 5 | 263 | 1.9 |
| NPK 23-10-5+4MgO+2Zn | 187 | 995 | 18.8 | 26 | 242 | 10.7 |
| NPK 15-15-15+9.6S+1B | 6 | 1,176 | 0.5 | 1 | 267 | 0.4 |
| NPK 12-30-17+0.4Zn | 6 | 1,176 | 0.5 | 1 | 267 | 0.4 |
| NPK 17-10-10 | 35 | 1,147 | 3.1 | 5 | 263 | 1.9 |
| NPK 4-18-13+3S+3MgO +6CaO+0.1B | 5 | 1,177 | 0.4 | 3 | 265 | 1.1 |
| Urea | 284 | 898 | 31.6 | 54 | 214 | 25.2 |
| AS | 275 | 907 | 30.3 | 54 | 214 | 25.2 |

### 5.6.2 *Formal Education and Fertilizer Use*

The distribution of fertilizer use by education is shown in Table 18. Farmers who had no formal education (52.1%) are differentiated from those who had at least a primary education (47.9%). The results show a mixed outcome, as the percentage of the users per non-user of some fertilizer types was higher for farmers with a formal education, while others were higher for farmers without formal education. For instance, farmers with a formal education who used NPK 15-15-15 formed about 54% of those who had formal education but did not use it. Conversely, those who had no formal education who used NPK 15-15-15 formed about 49% of those who had no formal education and did not use this fertilizer. While these trends were observed for fertilizer types such as NPK 20-10-10+3S+2MgO and AS, the reverse was observed for other fertilizers, such as NPK 15-20-20+0.7Zn, NPK 25-10-10, NPK 23-10-5+4MgO+2Zn, and urea.

*Table 18. Frequency distribution of formal education and fertilizer use*

| Fertilizer Type | Formally Educated | | | No Formal Education | | |
|---|---|---|---|---|---|---|
| | Users | Non-Users | % of Users per Non-Users | Users | Non-Users | % of Users per Non-Users |
| NPK 15-15-15 | 243 | 452 | 53.8 | 248 | 507 | 48.9 |
| NPK 15-20-20+0.7Zn | 138 | 557 | 24.8 | 183 | 572 | 32.0 |
| NPK 20-10-10+3S+2MgO | 74 | 621 | 11.9 | 41 | 714 | 5.7 |
| NPK 25-10-10 | 26 | 669 | 3.9 | 44 | 711 | 6.2 |
| NPK 21-10-10+2S | 14 | 681 | 2.1 | 14 | 741 | 1.9 |
| NPK 23-10-5+4MgO+2Zn | 87 | 608 | 14.3 | 126 | 629 | 20.0 |
| NPK 15-15-15+9.6S+1B | 2 | 693 | 0.3 | 5 | 750 | 0.7 |
| NPK 12-30-17+0.4Zn | 2 | 693 | 0.3 | 5 | 750 | 0.7 |
| NPK 17-10-10 | 12 | 683 | 1.8 | 28 | 727 | 3.9 |
| NPK 4-18-13+3S+3MgO +6CaO+0.1B | 1 | 694 | 0.1 | 7 | 748 | 0.9 |
| Urea | 178 | 517 | 34.4 | 160 | 595 | 26.9 |
| AS | 139 | 556 | 25.0 | 190 | 565 | 33.6 |

### 5.6.3 *Credit Access and Fertilizer Use*

Table 19 shows the percentage distribution of farmers based on their fertilizer use status and access to credit. As shown in Table 4, only about 14% of the farmers received credit during the cropping season. Also, farmers who obtained credit used it for all production activities and inputs, not necessarily for only purchasing fertilizers.

The results show that the percentage of farmers who used most of the fertilizer types per those who did not was higher among farmers who accessed credit than those who had no access to credit. For instance, while about 66% of users per non-user of NPK 15-15-15 were those farmers who had access to credit, only 49% of them were those who had no access to credit. A similar trend is seen for all other fertilizers except NPK 23-10-5+4MgO+2Zn and NPK 4-18-13+3S+3MgO +6CaO+0.1B. Considering that credit was a major limiting factor to use of fertilizer, this may well mean that improving farmers access to credit could enhance the use of fertilizer in the regions.

*Table 19. Frequency distribution of credit access and fertilizer use*

| | Access to credit | | | No access to credit | | |
|---|---|---|---|---|---|---|
| **Fertilizer Type** | **Users** | **Non-Users** | **% of Users per Non-Users** | **Users** | **Non-Users** | **% of Users per Non-Users** |
| NPK 15-15-15 | 81 | 123 | 65.9 | 410 | 836 | 49.0 |
| NPK 15-20-20+0.7Zn | 61 | 143 | 42.7 | 260 | 986 | 26.4 |
| NPK 20-10-10+3S+2MgO | 20 | 184 | 10.9 | 95 | 1,151 | 8.3 |
| NPK 25-10-10 | 11 | 193 | 5.7 | 59 | 1,187 | 5.0 |
| NPK 21-10-10+2S | 9 | 195 | 4.6 | 19 | 1,227 | 1.5 |
| NPK 23-10-5+4MgO+2Zn | 29 | 175 | 16.6 | 184 | 1,062 | 17.3 |
| NPK 15-15-15+9.6S+1B | 1 | 203 | 0.5 | 6 | 1,240 | 0.5 |
| NPK 12-30-17+0.4Zn | 1 | 203 | 0.5 | 6 | 1,240 | 0.5 |
| NPK 17-10-10 | 7 | 197 | 3.6 | 33 | 1,213 | 2.7 |
| NPK 4-18-13+3S+3MgO+6CaO +0.1B | 0 | 204 | 0.0 | 8 | 1,238 | 0.6 |
| Urea | 56 | 148 | 37.8 | 282 | 964 | 29.3 |
| AS | 59 | 145 | 40.7 | 270 | 976 | 27.7 |

### 5.6.4 *Access to Extension Services and Fertilizer Use*

Table 20 shows the distribution of farmers based on their access to extension services and fertilizer use status. As shown in Table 4, about 44% of the farmers had access to extension services during the cropping season. For most fertilizer types, a higher percentage of users per non-users was farmers who received extension services. For instance, among farmers who had access to extension services, the population of users of urea was about 40% of the non-users, while among the farmers without access to extension services, the population of users of urea was only 22% of the non-users. This indicates that, among farmers with access to extension services, there were four farmers who did use urea for every 10 farmers who did not. However, among the farmers without access to extension services, there were two farmers who used urea for every 10 farmers who did not. The trend was different for NPK 15-20-20+0.7Zn (which is largely promoted by PFJ program), as access to extension services did not appear to increase its use. With the wide media coverage of the PFJ program and the farmers' interactions with input dealers, it is possible that the farmers became aware of this fertilizer through these avenues rather than through the agricultural extension officers.

*Table 20. Frequency distribution of access to extension services and fertilizer use*

| | Access to Extension | | | No Access to Extension | | |
|---|---|---|---|---|---|---|
| **Fertilizer Type** | **Users** | **Non-Users** | **% of Users per Non-Users** | **Users** | **Non-Users** | **% of Users per Non-Users** |
| NPK 15-15-15 | 249 | 383 | 65.0 | 242 | 576 | 42.0 |
| NPK 15-20-20+0.7Zn | 112 | 520 | 21.5 | 209 | 609 | 34.3 |
| NPK 20-10-10+3S+2MgO | 55 | 577 | 9.5 | 60 | 758 | 7.9 |
| NPK 25-10-10 | 42 | 590 | 7.1 | 28 | 790 | 3.5 |
| NPK 21-10-10+2S | 16 | 616 | 2.6 | 12 | 806 | 1.5 |
| NPK 23-10-5 + 4MgO+2Zn | 98 | 534 | 18.4 | 115 | 703 | 16.4 |
| NPK 15-15-15+9.6S+1B | 3 | 629 | 0.5 | 4 | 814 | 0.5 |
| NPK 12-30-17+0.4Zn | 3 | 629 | 0.5 | 4 | 814 | 0.5 |
| NPK 17-10-10 | 9 | 623 | 1.4 | 31 | 787 | 3.9 |
| NPK 4-18-13+3S+3MgO+6CaO +0.1B | 0 | 632 | 0.0 | 8 | 810 | 1.0 |
| Urea | 180 | 452 | 39.8 | 158 | 660 | 23.9 |
| AS | 182 | 450 | 40.4 | 147 | 671 | 21.9 |

### 5.6.5 *Farmer-Based Organization Membership and Fertilizer Use*

Mass information/technology transfer is often carried out through farmer-based organizations (FBOs). Therefore, it is expected that farmers in FBOs may use fertilizer, since they may provide fertilizer information and human labor for fertilizer application to each other. The data show that only 25.2% of the farmers belonged to an FBO. As shown in Table 21, the percentage of the users of some fertilizer types (e.g., NPK 15-15-15, NPK 15-20-20+0.7Zn) per the non-users is higher among farmers who belonged to an FBO than those who did not. The reverse was observed for other fertilizer types, such as NPK 23-10-5+4MgO+2Zn and NPK 17-10-10. This suggests that FBO membership has a different effect on the use of different fertilizer types.

*Table 21. Frequency distribution of FBO membership and fertilizer use*

| | FBO Members | | | Non-FBO Members | | |
|---|---|---|---|---|---|---|
| **Fertilizer Type** | **Users** | **Non-Users** | **% of Users per Non-Users** | **Users** | **Non-Users** | **% of Users per Non-Users** |
| NPK 15-15-15 | 130 | 236 | 55.1 | 361 | 723 | 49.9 |
| NPK 15-20-20+0.7Zn | 96 | 270 | 35.6 | 225 | 859 | 26.2 |
| NPK 20-10-10+3S+2MgO | 35 | 331 | 10.6 | 80 | 1,004 | 8.0 |
| NPK 25-10-10 | 15 | 351 | 4.3 | 55 | 1,029 | 5.3 |
| NPK 21-10-10+2S | 4 | 362 | 1.1 | 24 | 1,060 | 2.3 |
| NPK 23-10-5+4MgO+2Zn | 41 | 325 | 12.6 | 172 | 912 | 18.9 |
| NPK 15-15-15+9.6S+1B | 1 | 365 | 0.3 | 6 | 1,078 | 0.6 |
| NPK 12-30-17+0.4Zn | 1 | 365 | 0.3 | 6 | 1,078 | 0.6 |
| NPK 17-10-10 | 6 | 360 | 1.7 | 34 | 1,050 | 3.2 |
| NPK 4-18-13+3S+3MgO +6CaO+0.1B | 0 | 366 | 0.0 | 8 | 1,076 | 0.7 |
| Urea | 88 | 278 | 31.7 | 250 | 834 | 30.0 |
| AS | 92 | 274 | 33.6 | 237 | 847 | 28.0 |

### 5.6.6 *Community Leadership Position and Fertilizer Use*

Table 22 shows the distribution of farmers who used fertilizer and their leadership status in the community. From the data, about 25.7% of the farmers held a leadership position in their communities. Among the farmers holding leadership position, 13.1% of them were females and 86.9% were males. Table 22 reveals mixed results, as a higher percentage of the users per the non-users of some fertilizer types were those farmers with a leadership position (e.g., NPK 15-20-20 +0.7Zn, NPK 25-10-10, and AS), while the percentage was higher among those without a leadership position for other fertilizer types (e.g., NPK 15-15-15 and urea).

*Table 22. Frequency distribution of community leadership position and fertilizer use*

| | Leader | | | Non-Leader | | |
|---|---|---|---|---|---|---|
| **Fertilizer Type** | **Users** | **Non-Users** | **% of Users per Non-Users** | **Users** | **Non-Users** | **% of Users per Non-Users** |
| NPK 15-15-15 | 121 | 252 | 48.0 | 370 | 707 | 52.3 |
| NPK 15-20-20+0.7Zn | 89 | 284 | 31.3 | 232 | 845 | 27.5 |
| NPK 20-10-10+3S+2MgO | 34 | 339 | 10.0 | 81 | 996 | 8.1 |
| NPK 25-10-10 | 34 | 339 | 10.0 | 36 | 1,041 | 3.5 |
| NPK 21-10-10+2S | 3 | 370 | 0.8 | 25 | 1,052 | 2.4 |
| NPK 23-10-5+4MgO + 2Zn | 38 | 335 | 11.3 | 175 | 902 | 19.4 |
| NPK 15-15-15+9.6S+1B | 0 | 373 | 0.0 | 7 | 1,070 | 0.7 |
| NPK 12-30-17+0.4Zn | 0 | 373 | 0.0 | 7 | 1,070 | 0.7 |
| NPK 17-10-10 | 12 | 361 | 3.3 | 28 | 1,049 | 2.7 |
| NPK 4-18-13+3S+3MgO +6CaO+0.1B | 3 | 370 | 0.8 | 5 | 1,072 | 0.5 |
| Urea | 72 | 301 | 23.9 | 266 | 811 | 32.8 |
| AS | 104 | 269 | 38.7 | 225 | 852 | 26.4 |

### 5.6.7 *Political Affiliation and Fertilizer Use*

The data show that 56.9% of the farmers indicated they had an affiliation with a political party in the country. Table 23 presents the distribution of the farmers based on their use of the various fertilizers and political affiliation. This shows that, for all fertilizer types, the percentage of users per the non-users among those without any political affiliation was higher than among those with a political affiliation. This indicates that being affiliated with a political party does not necessarily increase the use of fertilizers.

*Table 23. Frequency distribution of political affiliation and fertilizer use*

| Fertilizer Type | Affiliates | | | Non-Affiliates | | |
|---|---|---|---|---|---|---|
| | Users | Non-Users | % of Users per Non-Users | Users | Non-Users | % of Users per Non-Users |
| NPK 15-15-15 | 230 | 595 | 38.7 | 261 | 364 | 71.7 |
| NPK 15-20-20 + 0.7Zn | 179 | 646 | 27.7 | 142 | 483 | 29.4 |
| NPK 20-10-10+3S+2MgO | 44 | 781 | 5.6 | 71 | 554 | 12.8 |
| NPK 25-10-10 | 28 | 797 | 3.5 | 42 | 583 | 7.2 |
| NPK 21-10-10 +2S | 7 | 818 | 0.9 | 21 | 604 | 3.5 |
| NPK 23-10-5 + 4MgO + 2Zn | 87 | 738 | 11.8 | 126 | 499 | 25.3 |
| NPK 15-15-15 + 9.6S + 1B | 0 | 825 | 0.0 | 7 | 618 | 1.1 |
| NPK 12-30-17+ 0.4Zn | 0 | 825 | 0.0 | 7 | 618 | 1.1 |
| NPK 17-10-10 | 33 | 792 | 4.2 | 7 | 618 | 1.1 |
| NPK 4-18-13 + 3S + 3MgO + 6CaO + 0.1B | 3 | 822 | 0.4 | 5 | 620 | 0.8 |
| Urea | 141 | 684 | 20.6 | 197 | 428 | 46.0 |
| AS | 173 | 652 | 26.5 | 156 | 469 | 33.3 |

## 5.7 ICT and Fertilizer Application

Table 24 shows the assessment of the farmers' preferred means of receiving e-services and their willingness to patronize and pay for e-services. The results show that most of the farmers (83%) were willing to accept extension information on fertilizer through a mobile platform. Of these farmers, 89% prefer to access mobile phone-based extension and fertilizer information through phone calls, while about 9% and 2% preferred to receive information through short message service (SMS) and social media platforms, such as WhatsApp. The relatively low preference for text messaging and social media could be related to a low level of literacy and technology savviness of farmers, and thus, phone calls would make it easier for them to communicate in their local language and ask further clarification, with an immediate response when needed.

Among the farmers willing to accept information via mobile phone, about 63% are willing to pay for such services. On average, a farmer is willing to receive information about four times in a season and willing to pay about GHS 4.50 for a single bit of information. This result provides an opportunity for extension agents to deliver their services with limited person-to-person contact, which is critical to minimizing the spread of COVID-19. These results also offer the opportunity to design mobile-based technologies in the promotion of fertilizer use among farmers.

*Table 24. Frequency distribution of mobile phone technology and fertilizer information*

| Inquiry | Frequency | Percentage |
|---|---|---|
| ***Receive fertilizer information via phone*** | | |
| No | 245 | 16.9 |
| Yes | 1,205 | 83.1 |
| ***Most preferred medium of information*** | | |
| SMS | 105 | 8.7 |
| Call | 1,072 | 89.0 |
| Social media | 28 | 2.3 |
| ***Willingness to pay for information*** | | |
| No | 443 | 36.8 |
| Yes | 762 | 63.2 |
| ***Willingness to pay for single information*** | | |
| Zero | 689 | 47.5 |
| Above zero | 761 | 52.5 |
| | Mean | Std. Dev. |
| Willingness to pay for one time information (GHS) | 4.5 | 11.9 |
| Number of times to receive information per season | 3.4 | 2.5 |

# CHAPTER 6: FARMERS' MOTIVATION FOR USE AND NON-USE OF FERTILIZER

## 6.1 Motivations for Fertilizer Use

There are several reasons farmers use and do not use each fertilizer type. Table 25 shows the percentage of farmers who used a particular fertilizer and their major reasons for the use of each fertilizer type. The major reasons for using all fertilizer types were found to be that they lead to an increase in yields and make the crop healthy, ultimately leading to higher yields. The primary reason for promoting fertilizer use among farmers is to increase yields. Therefore, it is consistent that the farmers are motivated by such objectives in using the various fertilizers. The effect of availability on the use of fertilizer was mentioned by only a few farmers, implying most of the farmers would not make their decisions to use fertilizer based on such.

*Table 25. Frequency distribution of the reasons for using various fertilizer types*

| | Users | | Reasons for Using Fertilizer Type (% of Users) | | | | |
|---|---|---|---|---|---|---|---|
| Fertilizer Type | Freq. | % | Makes the Crop Healthy | Increase Yield | Readily Available | Less Expensive as Compared to Others | Trust in Fertilizer Type |
| NPK 15-15-15 | 491 | 33.9 | 57.6 | 64.2 | 43.8 | 10.6 | 18.5 |
| NPK 15-20-20+0.7Zn | 321 | 22.1 | 36.4 | 81.0 | 56.4 | 11.2 | 14.6 |
| NPK 20-10-10+3S+2MgO | 115 | 7.9 | 32.2 | 60.9 | 32.2 | 5.2 | 13.9 |
| NPK 25-10-10 | 70 | 4.8 | 75.7 | 80.0 | 67.1 | 24.3 | 35.7 |
| NPK 21-10-10+2S | 28 | 1.9 | 57.1 | 78.6 | 60.7 | 10.7 | 28.6 |
| NPK 23-10-5+4MgO+2Zn | 213 | 14.7 | 53.5 | 57.7 | 35.7 | 3.8 | 16.0 |
| NPK 15-15-15+9.6S+1B | 7 | 0.5 | 71.4 | 42.9 | 14.3 | 0.0 | 0.0 |
| NPK 12-30-17+0.4Zn | 7 | 0.5 | 28.6 | 71.4 | 28.6 | 14.3 | 14.3 |
| NPK 17-10-10 | 40 | 2.8 | 40.0 | 92.5 | 40.0 | 7.5 | 22.5 |
| NPK 4-18-13+3S+3MgO +6CaO+0.1B | 8 | 0.6 | 25.0 | 100.0 | 0.0 | 0.0 | 0.0 |
| Urea | 338 | 23.3 | 40.2 | 87.0 | 45.3 | 10.7 | 17.5 |
| AS | 329 | 22.7 | 49.9 | 83.6 | 43.5 | 13.1 | 21.9 |

*Note: This was multiple response. Therefore, the frequencies do not add up to 1,450 and the percentages do not add up to 100.*

## 6.2 Farmers' Expectations of the Fertilizer Types

Figure 12 presents information on the extent to which farmers who used fertilizers (Table 26) were satisfied with the performance of the various fertilizer types by comparing their *a priori* expectations with the results from the application of each fertilizer type. The majority of the users of the various fertilizers were generally satisfied with the results of the fertilizer. All farmers who applied NPK 15-15-15+9.6S+1B were satisfied with its performance, but this was only seven farmers. No less than 80% of the users of the various fertilizers, except for NPK 12-30-17+0.4Zn, were satisfied with the results.

Table 26 also details the reasons for which farmers expectations were met. Yield and underlying soil fertility improvements were the main conditions that were satisfied for the farmers. From key informant interviews, the major reasons for which farmers apply fertilizers include increased crop yield, increased household income, maintenance of soil fertility, and proper development of crops.

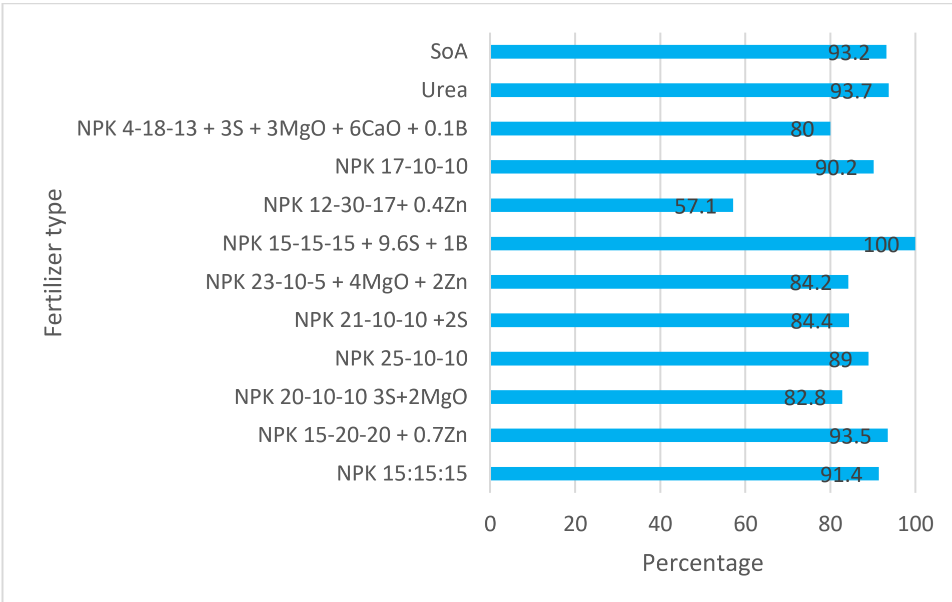



***Figure 12. Percentage distribution of farmers' satisfaction with outcomes from fertilizer use***

***Table 26. Frequency distribution of the prime reasons why expectations are met***

| Fertilizer Type | Increased Soil Fertility | Obtained Higher Yield | Increased Grain/Tuber Size | Total Frequency |
|---|---|---|---|---|
| NPK 15-15-15 | 28.8 | 64.6 | 3.8 | 444 |
| NPK 15-20-20+0.7Zn | 23.4 | 68.9 | 6.3 | 286 |
| NPK 20-10-10+3S+2MgO | 24.4 | 63.4 | 7.3 | 82 |
| NPK 25-10-10 | 13.8 | 55.4 | 12.3 | 65 |
| NPK 21-10-10+2S | 37.0 | 66.7 | 0.0 | 27 |
| NPK 23-10-5+4MgO+2Zn | 26.3 | 61.3 | 11.8 | 186 |
| NPK 15-15-15+9.6S+1B | 100.0 | 57.1 | 0.0 | 7 |
| NPK 12-30-17+0.4Zn | 125.0 | 50.0 | 0.0 | 4 |
| NPK 17-10-10 | 18.9 | 75.7 | 2.7 | 37 |
| NPK 4-18-13+3S+3MgO+6CaO+0.1B | 25.0 | 87.5 | 12.5 | 8 |
| Urea | 22.8 | 58.1 | 15.8 | 329 |
| AS | 16.9 | 55.9 | 28.8 | 313 |

*Note: This was multiple response. Each percentage under each fertilizer type was computed from the respective total frequency.*

## 6.3 Demotivational Factors to Fertilizer Use

Table 27 shows that the major demotivational factors toward the use of the various fertilizer types included a lack of funds/capital, unavailability of the fertility type, and a lack of knowledge about the existence of the fertilizer type. Specifically, the highest percentage of farmers did not use AS, urea, NPK 23-10-5+4MgO+2Zn, NPK 25-10-10, NPK 20-10-10+3S+2MgO, and NPK 15-15-15 because they did not have enough capital to invest in fertilizer purchasing and use. For NPK 15-20-20+0.7Zn, the major demotivational factor was its low availability. Most of the farmers did not use NPK 4-18-13+3S+3MgO+6CaO+0.1B, NPK 17-10-10, and NPK 12-30-17+0.4Zn+NPK 15-15-9.6S+1B because they were not aware of these fertilizers. These results are consistent with challenges to the use of fertilizer (Table 16).

*Table 27. Frequency distribution of the reasons for not using various fertilizer types*

| | Non-Users | | Reason for Not Using Fertilizer (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Fertilizer Type** | **Freq.** | **%** | **Unavailability** | **Expensive** | **Unaware** | **Lack of Capital/ Fund** | **Inefficient for Crops/Farm Land** | **Do Not Need Fertilizer** | **No Reason** |
| NPK 15-15-15 | 959 | 66.1 | 30.7 | 25.0 | 13.5 | 42.6 | 7.1 | 16.0 | 4.2 |
| NPK 15-20-20 +0.7Zn | 1129 | 77.9 | 38.0 | 12.7 | 25.2 | 36.6 | 9.0 | 14.6 | 6.4 |
| NPK 20-10-10 +3S+2MgO | 1335 | 92.1 | 34.2 | 12.9 | 30.2 | 37.7 | 7.3 | 13.6 | 7.3 |
| NPK 25-10-10 | 1380 | 95.2 | 32.4 | 12.2 | 26.9 | 38.6 | 6.1 | 12.8 | 7.5 |
| NPK 21-10-10 +2S | 1422 | 98.1 | 32.4 | 11.3 | 33.1 | 36.0 | 6.7 | 13.4 | 7.5 |
| NPK 23-10-5 +4MgO+2Zn | 1237 | 85.3 | 30.0 | 11.2 | 37.4 | 35.6 | 6.4 | 14.8 | 7.2 |
| NPK 15-15-15 +9.6S+1B | 1443 | 99.5 | 32.6 | 9.4 | 35.8 | 34.4 | 6.1 | 11.8 | 7.6 |
| NPK 12-30-17 +0.4Zn | 1443 | 99.5 | 30.1 | 9.9 | 37.6 | 36.7 | 6.8 | 12.1 | 7.1 |
| NPK 17-10-10 | 1410 | 97.2 | 28.9 | 10.8 | 37.0 | 36.9 | 6.8 | 13.5 | 7.2 |
| NPK 4-18-13+3S +3MgO+6CaO +0.1B | 1442 | 99.4 | 30.3 | 8.3 | 42.6 | 33.5 | 6.4 | 12.4 | 6.0 |
| Urea | 1112 | 76.7 | 20.7 | 14.6 | 16.2 | 40.8 | 11.1 | 16.8 | 9.9 |
| AS | 1121 | 77.3 | 23.1 | 15.1 | 17.0 | 41.6 | 8.7 | 13.8 | 8.7 |

*Note: This was multiple response. Each percentage was obtained from the total frequency of non-users; therefore, they will not add up to 100.*

# CHAPTER 7: FOOD AND NUTRITIONAL SECURITY STATUS OF HOUSEHOLDS

## 7.1 Food Consumption Expenditure

Table 28 presents the average food consumption expenditure and its components. During the data collection process, the households were asked to provide expenditure values for their own and purchased food items. Thus, assuming they were to buy every food item, the amount they would have spent was determined. When the respondents were able to provide the quantity of their own specific food products consumed, market prices were estimated and used. Therefore, the food consumption expenditure provided in Table 28 represents a combination of the households' own and purchased food consumption expenditures. On average, a household spent about GHS 6,915.3 on food annually. On a per capita basis, the average food consumption expenditure was about GHS 1,070, which is lower than the GHS 1,931.0 average food consumption expenditure of Ghana and the GHS 1,411 of rural households in the country (GSS, 2019b). However, when size was adjusted to account for differences in consumption for different aged individuals in the household, the average household food consumption expenditure was GHS 2,514. Thus, a typical adult in a household spent GHS 2,514 annually on food. This adjustment helps to resolve the differences in quantities of food as well as food consumption expenditure among children and adults.

Comparatively, cereals, roots and tubers, and animal protein constitute the major components of the household food expenditure. The purchasing pattern does reveal households aim to diversify the diet. The country-level data suggest that cereals and bread were the major contributors to the food consumption expenditure of the households (GSS, 2019b).

*Table 28. Descriptive statistic of annual food consumption expenditure of households*

| Food Component (Weekly) | Mean (GHS) | Std. | Min | Max |
|---|---|---|---|---|
| Cereal crops (e.g., maize, rice) | 42.5 | 46.3 | 2 | 300 |
| Root and tuber crops (e.g., cassava, yam) | 33.5 | 33.3 | 1 | 150 |
| Legume crops (e.g., cowpea) | 12.9 | 10.4 | 2 | 55 |
| Vegetables (e.g., tomato) | 12.2 | 13.2 | 1 | 150 |
| Sauces/spices | 6.3 | 5.6 | 0.5 | 30 |
| Animal protein sources (e.g., meat, fish, egg) | 33.5 | 38.4 | 1 | 300 |
| Non-alcoholic beverages | 11.2 | 10.8 | 1 | 100 |
| Alcoholic drinks and tobacco | 10.2 | 9.0 | 1 | 100 |
| Fruits | 8.1 | 6.1 | 1 | 30 |
| Milk and milk products | 8.8 | 7.1 | 1 | 54 |
| Bread, sugar, honey, and confectionery | 12.0 | 10.6 | 1 | 80 |
| Total weekly expenditure | 133.0 | 124.4 | 10 | 880 |
| Total annual expenditure | 6,915.3 | 5,727.0 | 208 | 45,760 |
| Per capita food expenditure (annual) | 1,069.5 | 1,817.5 | 18.9 | 24,960 |
| Adjusted per capita food expenditure | 2,513.5 | 2,583.1 | 156.8 | 25,740 |

*Note: The square root scale method was used to adjust the household size.*

## 7.2 Household Dietary Diversity Score

### 7.2.1 *Components of the Household Dietary Diversity Score*

Table 29 shows the food categories used in the computation of the Household Dietary Diversity Score (HDDS). These are standardized components as provided by the guidelines of FAO (2010) and the Food and Nutrition Technical Assistance (FANTA) (Swindale and Bilinsky, 2006). The method requires that households' recall information on the various food types consumed during the 24 hours prior to the time of the data collection.

The results show that about 92% of the sampled farmers consumed vegetables, spices, condiments, and beverages, while about 91% consumed cereals. The data further show that 57% consumed root and tubers, 59% consumed legumes, 72% consumed sweets, and 85% consumed fish and other seafood. Less than half the sample consumed the other food groups within the past 24 hours. For instance, 42%, 45%, and 42% of the sampled households consumed fruits, meat, and eggs, respectively. The consumption of milk and milk products was very low, since, as only about one in every five household consumed these items in the 24 hours before data collection.

Theoretically, HDDS ranges between 1 and 12 and the desired result is a higher HDDS. The higher the HDDS, the higher the diversity in the diets of the households. As explained by Swindale and Bilinsky (2006), a more diversified diet is highly correlated with factors such as caloric and protein adequacy as well as household income. This justifies the appropriateness of using HDDS in explaining the food security status of households. The mean HDDS was 7.6, indicating that an average sampled farm household had one unit of dietary diversity above the median of 6.5.

***Table 29. Descriptive statistics of the components of HDDS***

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Cereals | 0.9 | 0.29 | 0 | 1 |
| White tubers and roots | 0.6 | 0.50 | 0 | 1 |
| Vegetables | 0.9 | 0.26 | 0 | 1 |
| Fruits | 0.4 | 0.49 | 0 | 1 |
| Meat | 0.5 | 0.50 | 0 | 1 |
| Eggs | 0.4 | 0.49 | 0 | 1 |
| Fish and other seafood | 0.9 | 0.35 | 0 | 1 |
| Legumes, nuts, and seeds | 0.6 | 0.49 | 0 | 1 |
| Milk and milk products | 0.2 | 0.42 | 0 | 1 |
| Oils and fats | 0.6 | 0.49 | 0 | 1 |
| Sweet | 0.7 | 0.45 | 0 | 1 |
| Spices, condiments, and beverages | 0.9 | 0.27 | 0 | 1 |
| HDDS | 7.6 | 2.28 | 1 | 12 |

Consistent with Swindale and Bilinsky (2006), some households were completely nondiverse while others were completely diverse in their dietary consumption. Figure 13 shows the percentage distribution of households within the HDDS scale and the categorization of households into four categories. From the left panel, about 68.6% of the households had an HDDS of more than 7. The majority (16.1%) of the households had an HDDS score of 9, while 15.7% and 15.1% of the households had an HDDS of 7 and 8, respectively. While only 0.4% had an HDDS of 1, 3.2% of the households had completely diversified diets. This distribution is simplified in the right panel, which shows that the majority (47%) of the households had moderate (7-9) HDDS scores. However, with 31% of the households having low or mild dietary diversity, policies and programs must target the increase in dietary diversity of these farm households to improve the nutritional security of the households.

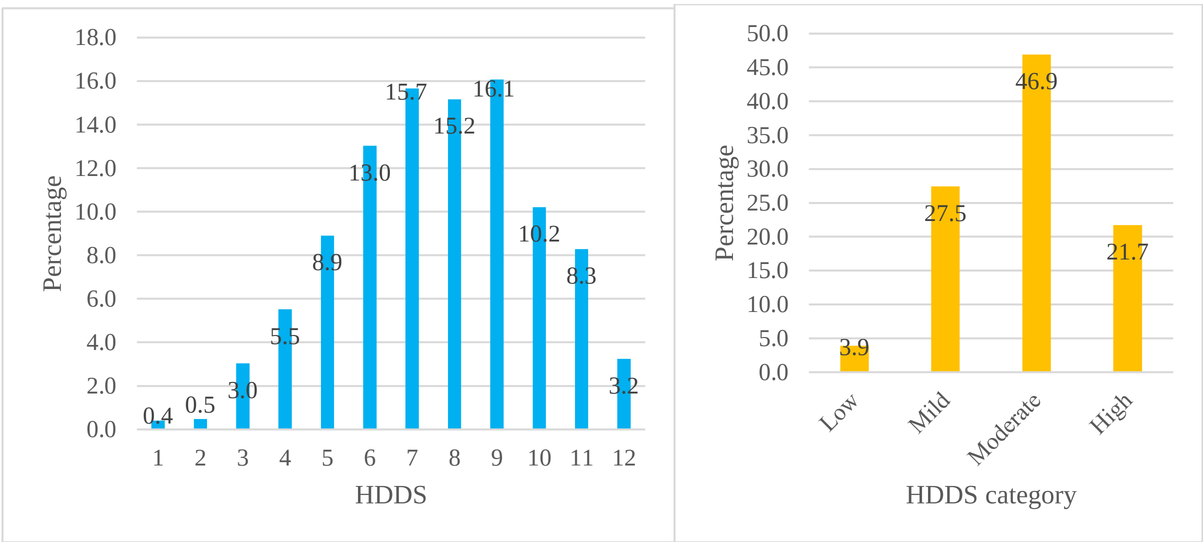



***Figure 13. Percentage distribution of HDDS***

Table 30 shows the regional disaggregation of HDDSs. Households in the Upper East Region recorded the highest average HDDS (9.0) and the Upper West Region recorded the lowest (6.1). The minimum values also show that four out of the nine regions had higher minimum HDDSs, while North East and Ahafo regions had no household with complete dietary diversity. The ANOVA statistic shows that there was a statistically significant difference in the HDDSs among the regions.

***Table 30. Descriptive statistics of the regional distribution of HDDS***

| Region | Mean HDDS[a] | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Northern | 7.9 | 1.94 | 3 | 12 |
| North East | 6.3 | 2.03 | 1 | 11 |
| Savannah | 8.7 | 1.85 | 3 | 12 |
| Upper East | 9.0 | 2.09 | 1 | 12 |
| Upper West | 6.1 | 2.16 | 1 | 12 |
| Bono | 8.0 | 2.21 | 3 | 12 |
| Bono East | 7.5 | 2.52 | 1 | 12 |
| Ahafo | 7.5 | 1.68 | 3 | 11 |
| All regions | 7.6 | 2.28 | 1 | 12 |

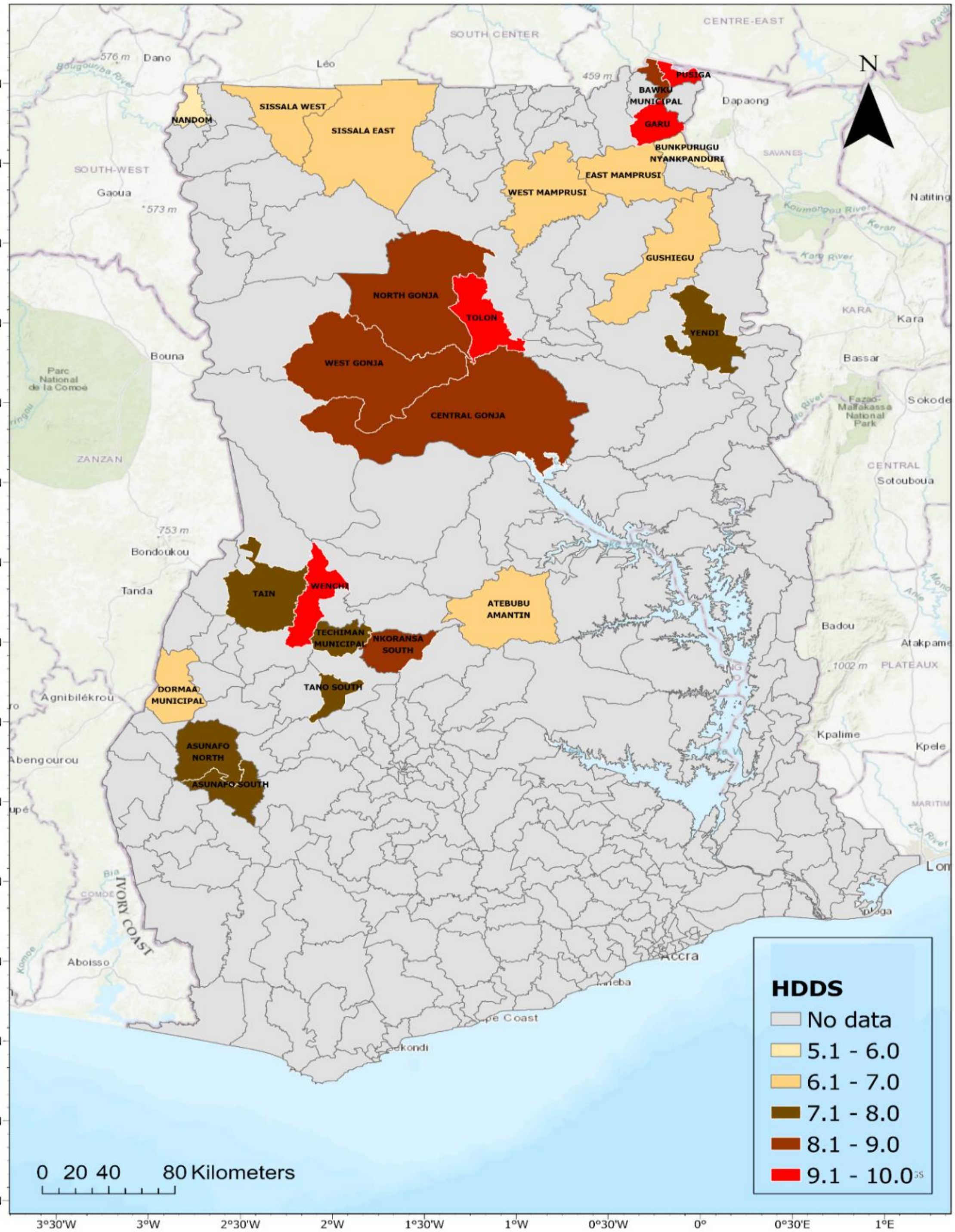
a. *F-statistic = 43.76; Prob > F-value =0.000.*

Table 31 shows the percentage of households that combine each food component with other components. Households with an HDDS of 1 consumed only cereals or vegetables or fruits in the 24 hours prior to data collection. The households consumed legumes, nuts, and seeds with at least two other food components. This was similar for households that consumed eggs and oil and fats.

*Table 31. Percentage of households under each HDDS score with respect to consumption of food component*

| Food Component | % of Households Consuming Each Food Item With Respect to HDDS | | | | | | | | | | | | Total Freq. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HDDS 1 | HDDS 2 | HDDS 3 | HDDS 4 | HDDS 5 | HDDS 6 | HDDS 7 | HDDS 8 | HDDS 9 | HDDS 10 | HDDS 11 | HDDS 12 | |
| Cereals | 0.2 | 0.3 | 2.4 | 4.7 | 8.5 | 12.3 | 15.3 | 15.9 | 17.5 | 10.5 | 9.0 | 3.6 | 1,318 |
| White tubers and roots | 0.0 | 0.2 | 1.0 | 3.0 | 5.5 | 10.1 | 13.3 | 14.9 | 19.1 | 14.8 | 12.3 | 5.7 | 820 |
| Eggs | 0.0 | 0.0 | 0.3 | 1.3 | 5.2 | 8.5 | 10.7 | 12.8 | 22.8 | 13.8 | 16.9 | 7.6 | 615 |
| Fish and other seafood | 0.0 | 0.1 | 1.1 | 4.3 | 7.3 | 11.9 | 16.2 | 16.6 | 17.3 | 11.8 | 9.6 | 3.8 | 1,237 |
| Legumes, nuts, and seeds | 0.0 | 0.0 | 0.8 | 1.7 | 2.8 | 8.5 | 15.2 | 17.6 | 21.1 | 14.2 | 12.6 | 5.5 | 858 |
| Milk and milk products | 0.0 | 0.3 | 0.6 | 0.6 | 1.2 | 3.2 | 9.4 | 12.9 | 15.0 | 20.2 | 22.9 | 13.8 | 341 |
| Oils and fats | 0.0 | 0.0 | 0.6 | 1.2 | 2.3 | 7.3 | 12.0 | 18.3 | 22.9 | 16.2 | 13.7 | 5.6 | 840 |
| Sweets | 0.0 | 0.1 | 0.2 | 0.6 | 4.6 | 9.0 | 16.7 | 18.6 | 20.9 | 13.7 | 11.2 | 4.5 | 1,050 |
| Meat | 0.0 | 0.2 | 0.8 | 1.2 | 3.8 | 5.8 | 11.1 | 13.6 | 21.8 | 17.1 | 17.5 | 7.2 | 656 |
| Spices, condiments, and beverages | 0.0 | 0.2 | 1.7 | 4.7 | 8.1 | 12.7 | 16.0 | 16.1 | 17.1 | 11.0 | 9.0 | 3.5 | 1,331 |
| Vegetables | 0.1 | 0.3 | 2.1 | 4.3 | 8.3 | 12.3 | 16.3 | 15.9 | 17.1 | 11.0 | 8.9 | 3.5 | 1,341 |
| Fruits | 0.2 | 0.0 | 1.0 | 1.8 | 4.5 | 5.0 | 11.6 | 13.9 | 18.6 | 18.5 | 17.3 | 7.8 | 606 |

Figure 14 shows the graphical distribution of the HDDSs among the selected districts. This shows that dietary diversity is highest in Tolon, Pusiga, Garu, and Wenchi Municipal districts and lowest in Nabdom and Bunkpurugu/Nyankpanduri districts.




*Note: Red color grades indicate improved food security.*

***Figure 14. Household Dietary Diversity Score among districts***

### 7.2.2 *Setting the HDDS Target*

Figure 15 shows the average income of the terciles and the average HDDS of the income terciles. This analysis is necessary in setting the HDDS target for any project (FAO, 2010). The results show the average total income of the richest 33% of the sampled households was GHS 14,274.24, while that of the poorest 33% of the sampled households was GHS 1,451.57. On the other hand, the richest 33% had an average HDDS of 7.8, while the poorest 33% had an average HDDS of 7.47. FAO's guideline on HDDS suggest that the average HDDS of the richest 33% (richest tercile) should be the target a project should aim at achieving. The implication is that any intervention (for instance, nutritional education programs) within the studied regions that seeks to improve the food and nutritional security of farm households should aim at improving the HDDS of households beyond 7.8. However, it is important to note that FERARI's target is to increase food availability and nutritional quality of food crops, not necessarily to promote diversification of food components.

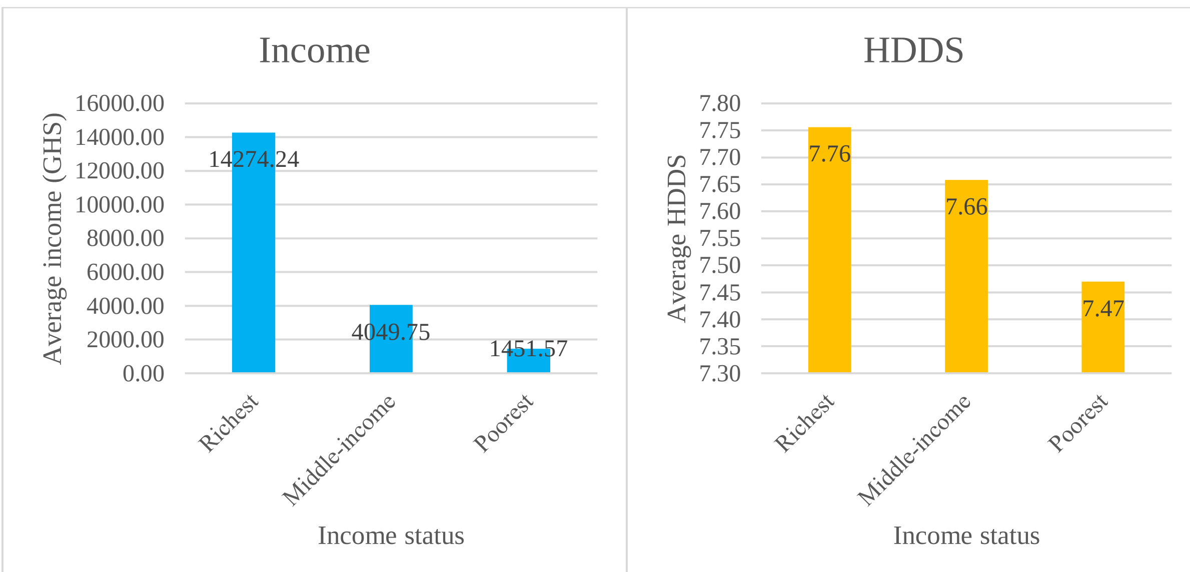



***Figure 15. Terciles in income and associated HDDS for setting targets to increase dietary diversity***

## 7.3 Household Food Insecurity Access Scale

### 7.3.1 *Components of Household Food Insecurity Access Scale*

The Household Food Insecurity Access Scale (HFIAS) is a tool used to measure the access component of food security. It helps to understand the changes in the food security of a population over time. The HFIAS includes nine standardized questions from which an index is generated. The questions require memory recall from participants (in this case, farm households) over the past four weeks up to the day of the interview.

Figure 16 shows the components of HFIAS and the percentage of farmers who experienced food hardship problems in the prior four weeks. From this result, only two components included more than half the sample size. Specifically, at least one member each in about 52% households was unable to eat their preferred foods because of a lack of resources and one each in 51% households ate a limited variety of foods due to a lack of resources. At least one member each in 44% of the sampled households ate some foods that they really did not want to eat but were compelled to by the lack of resources, while about 37% of the sampled households worried that at least a member of their household did not get enough food to eat within the past four weeks. Only a few of the sampled households (less than 10%) reported that at least one member of their household went a whole day and night without eating anything because there was not enough food or at least one household member went to sleep at night hungry because there was not enough food. As mentioned previously, the average HDDS score of the farmers was 7.6, with about 18% of households consuming no more than five out of 12 food items. This indicates that measures must be taken to improve access to diverse food items or enhance the ability to access the most preferred food items by the households.

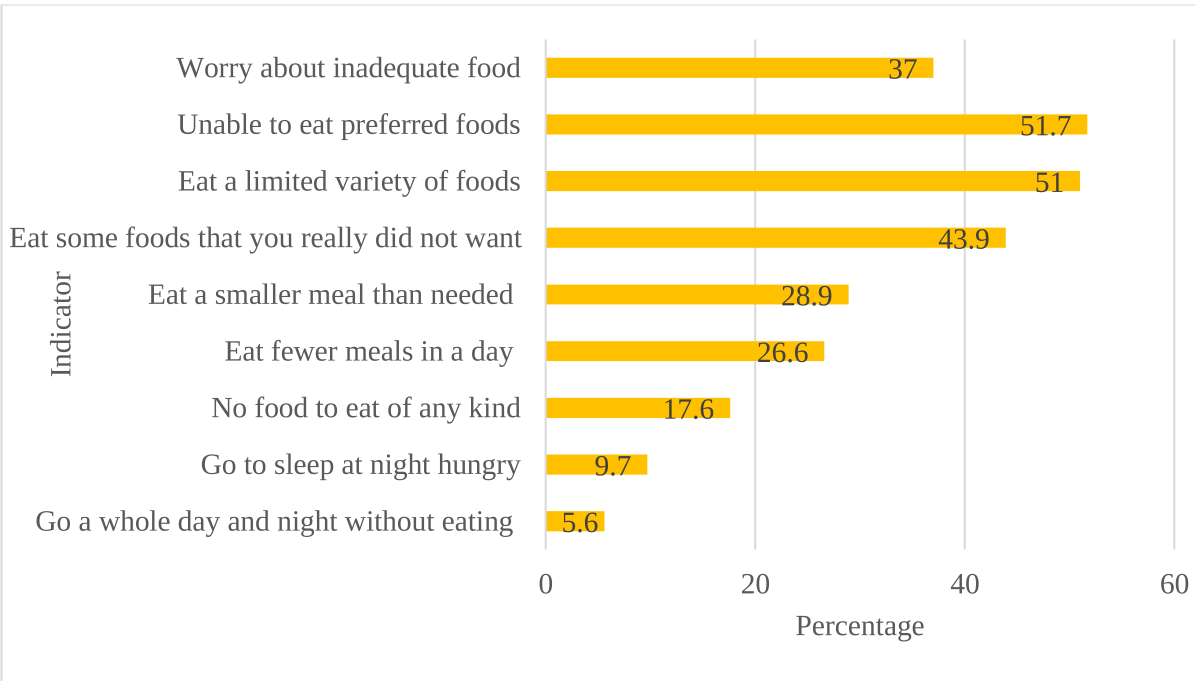



***Figure 16. Percentage distribution of the components of the Household Food Insecurity Access Scale and prevalence***

Figure 17 shows the percentage distribution of the frequency of occurrence for those who indicated experiencing any of the food hardship indicators. The results show that the frequency of occurrence for most components was rare. Only two indicators had more than 10% of the households indicating their occurrence more than 10 times within the previous four weeks. The general implication is that, when appropriate strategies are used, the severity of food hardship among all the farming households can be minimized.

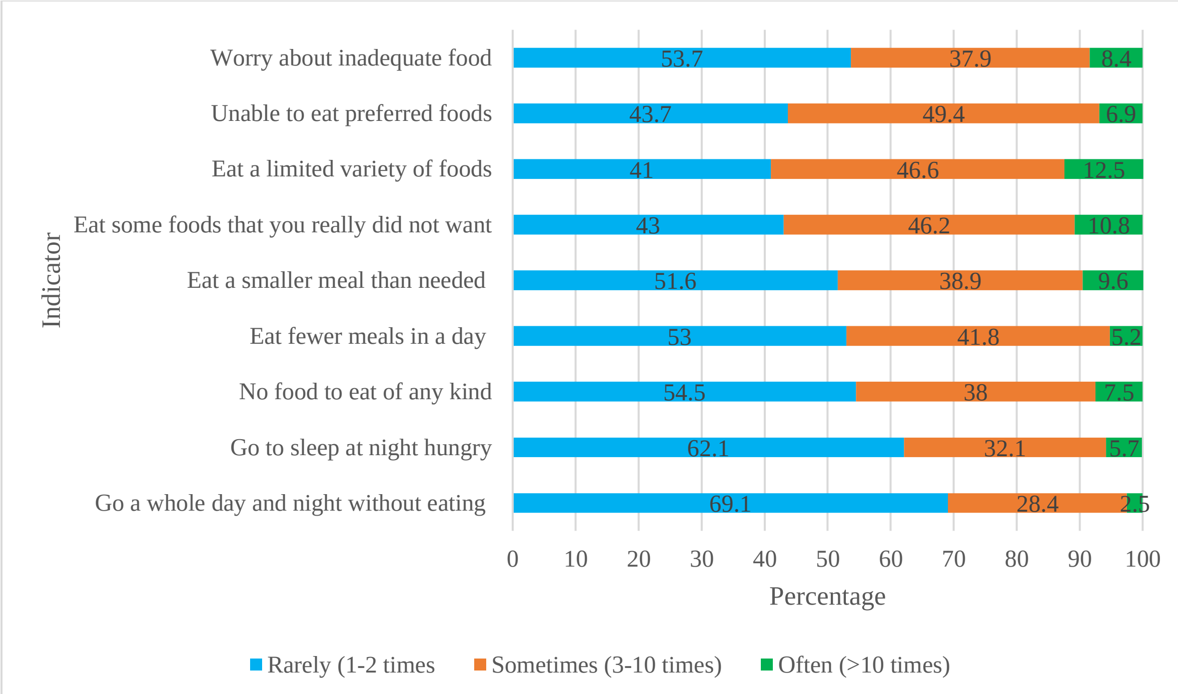



***Figure 17. Percentage distribution of the frequency of occurrence of food insecurity indicators***

### 7.3.2 *Household Food Insecurity Access Scale Score and Prevalence*

HFIAS is estimated by the summation of the occurrences of the access scale indicators shown in Figures 16 and 17 (0-no occurrence, 1-rare, 2-sometimes, and 3-often). Therefore, the HFIAS ranges from 0 to 27. The higher the HFIAS value, the greater the food insecurity. The mean HFIAS value in this study was 4.4, with a minimum of 0 and a maximum of 27, which implies that the experience of food insecurity (access) was low among the households. The next step in HFIAS analysis is to categorize households into four prevalence levels of food insecurity. This is shown in Figure 18 as food secure, mildly food insecure, moderately food insecure, and severely food insecure.

**Definition of Food Security Status**

- *"A food secure household experiences none of the food insecurity (access) conditions, or just experiences worry, but rarely.*
- *A mildly food insecure (access) household worries about not having enough food sometimes or often, and/or is unable to eat preferred foods, and/or eats a more monotonous diet than desired and/or some foods considered undesirable, but only rarely. But it does not cut back on quantity nor experience any of three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating).*
- *A moderately food insecure household sacrifices quality more frequently, by eating a monotonous diet or undesirable foods sometimes or often, and/or has started to cut back on quantity by reducing the size of meals or number of meals, rarely or sometimes. But it does not experience any of the three most severe conditions.*
- *A severely food insecure household has graduated to cutting back on meal size or number of meals often, and/or experiences any of the three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating), even as infrequently as rarely. In other words, any household that experiences one of these three conditions even once in the last four weeks (30 days) is considered severely food insecure."*

*Source:* Coates et al. (2007)

The highest percentage of (35%) of the households indicated moderate food insecurity. The results establish that 34% of the sampled farm households were food secure, while 13% were mildly food insecure. On the other hand, about 18% of the households were severely food insecure. Recalling the HDDS and juxtaposing this with the HFIAS, it can be concluded that there was moderate food insecurity among the households. Evidence shows that 74% of households in the northern regions (Northern, Savannah, North East, Upper East, and Upper West) are food secure, while only 2% are severely food insecure (WFP, 2012). ISSER (2013) also indicates that, while 10% of northern rural households are food insecure, an additional 17% are vulnerable to becoming food insecure. Using the household hunger scale, however, Nkegbe et al. (2017) also found that about 36% of households in the Northern and Brong-Ahafo regions are moderately food insecure and only about 1% are severely food insecure.

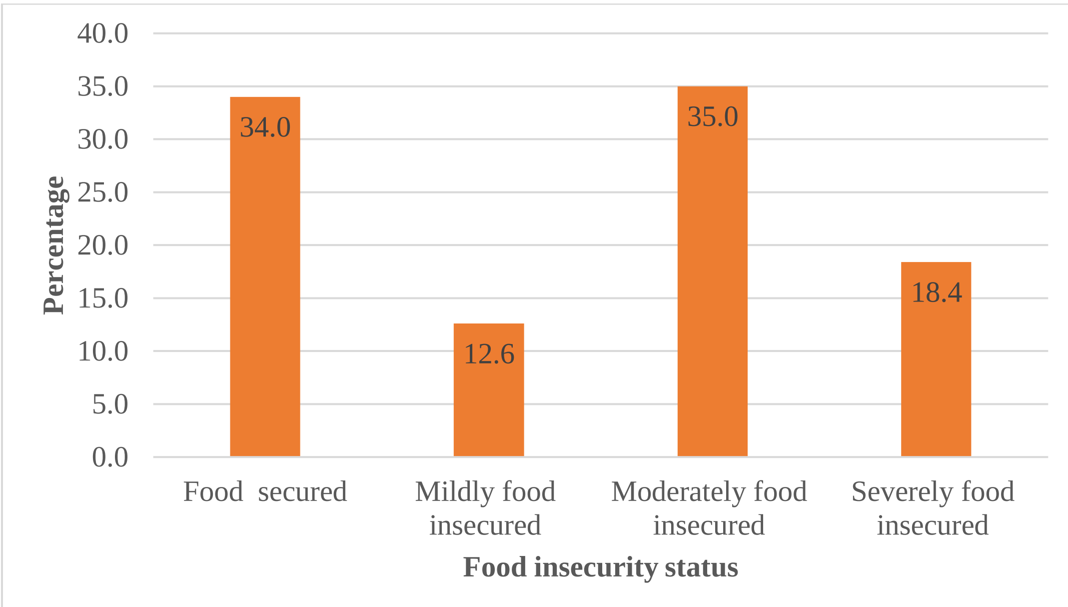


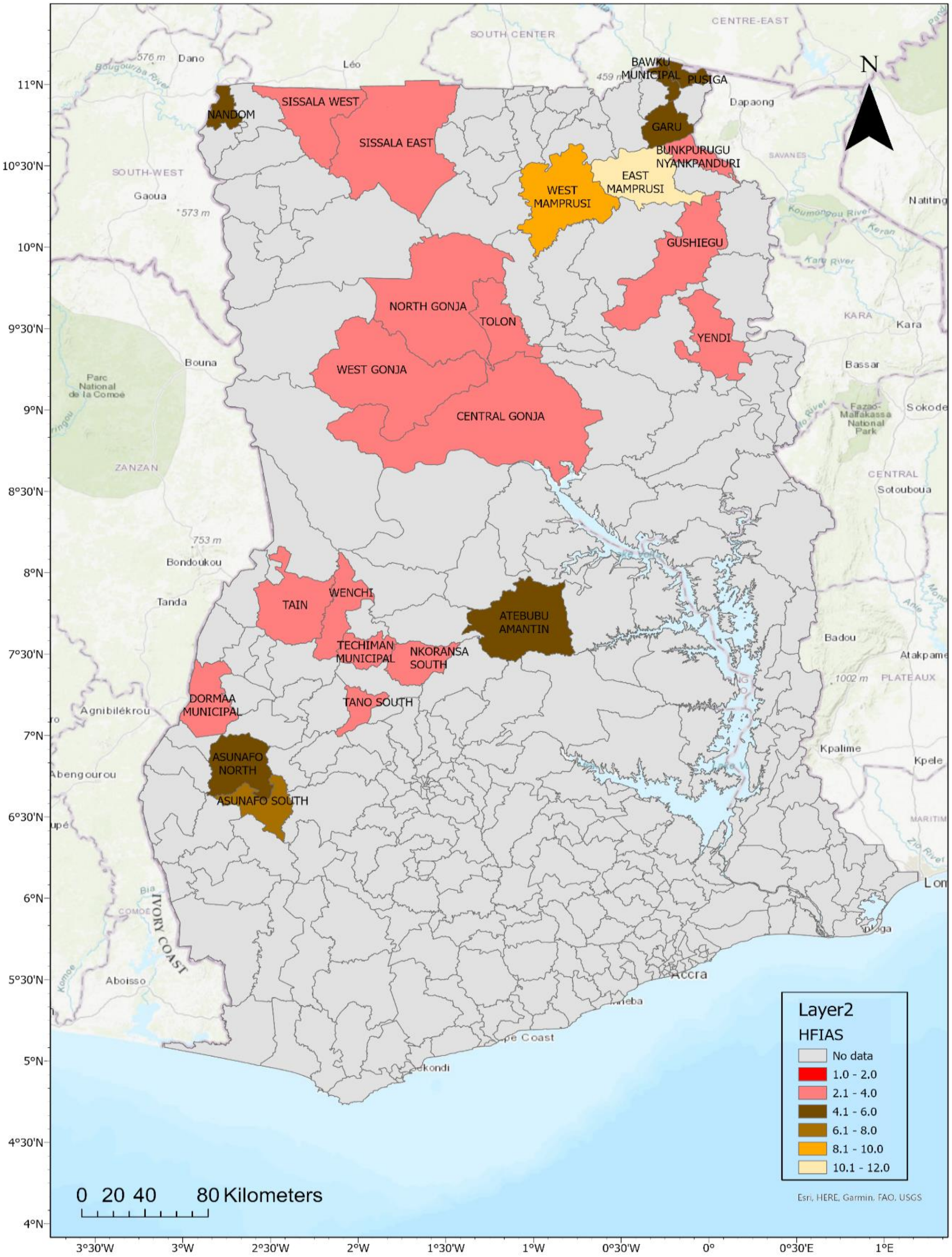

***Figure 18. Percentage distribution of HFIAS classification***

Table 32 shows the regional disaggregation of the food insecurity status among the sampled farm households. Food secure households were dominant in the Bono East Region and the lowest in the North East Region. On the other hand, severe food insecurity was high among households in North East Region and the lowest in the Northern Region. Regionally, the United Nations World Food Programme (WFP, 2012) found that 38%, 24%, and 20% of households were food insecure in Upper East, Upper West and Northern (now Northern, Savannah, and North East) regions, respectively.

Figure 19 shows the mean distribution of HFIAS by the selected districts. Food access was higher in most of the selected districts, especially those in the Northern, Savannah, and Bono East regions. The distribution of HFIAS categories by district is shown in Appendices 1a-1d.

*Table 32. Frequency distribution of food insecurity status by region*

| Region | Food Secure | | Mildly Food Insecure | | Moderately Food Insecure | | Severely Food Insecure | |
|---|---|---|---|---|---|---|---|---|
| | **Freq.** | **%** | **Freq.** | **%** | **Freq.** | **%** | **Freq.** | **%** |
| Northern | 60 | 34 | 36 | 20 | 81 | 45 | 2 | 1 |
| North East | 9 | 5 | 19 | 11 | 66 | 37 | 87 | 48 |
| Savannah | 84 | 48 | 18 | 10 | 64 | 37 | 9 | 5 |
| Upper East | 42 | 24 | 9 | 5 | 87 | 49 | 41 | 23 |
| Upper West | 62 | 35 | 19 | 11 | 64 | 36 | 34 | 19 |
| Bono | 69 | 38 | 30 | 17 | 64 | 36 | 17 | 9 |
| Bono East | 105 | 57 | 16 | 9 | 41 | 22 | 22 | 12 |
| Ahafo | 57 | 32 | 34 | 19 | 36 | 20 | 52 | 29 |
| Total | 488 | 34 | 181 | 13 | 503 | 35 | 264 | 18 |




*Note: Red color grades indicate improved food security.*

***Figure 19. Household food insecurity access scale among selected districts***

## 7.4 Strategies to Cope With Food Insecurity

Table 33 reports the coping strategies employed by households to mitigate food insecurity challenges. Notable among the coping strategies are consumption of less expensive foods, consumption of low-quality foods, elimination of some components from meals, consumption of less preferred foods, and restriction of the consumption of adults to enable children have enough food to eat. The least used coping strategies include migrating, sending household members to eat elsewhere, making handicrafts to raise money, and sending household members to beg for food. On average, a household adopted about four strategies to cope with food insecurity. It is important to recall that the consumption of less preferred foods and fewer varieties of foods due to limited resources were the major contributors to the HFIAS, and these are consistent with the results, such as the consumption of less preferred foods, consumption of low-quality foods, and reliance on less expensive foods, in Figure 16. Further analysis of the food consumption expenditure shows that the food secure households (using HFIAS classification) had an average annual income of GHS 7,335.5 and made an average annual food expenditure of GHS 3,332, while food insecure households had an average annual income of GHS 5,493.4 and an average annual food expenditure of GHS 2,260.

*Table 33. Descriptive statistics of the coping strategies to food insecurity*

| Coping Strategy | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Skip meals | 0.4 | 0.48 | 0 | 1 |
| Restrict consumption of adults so small children can eat | 0.4 | 0.48 | 0 | 1 |
| Limited portion size at mealtimes | 0.4 | 0.49 | 0 | 1 |
| Send (ask) household members to eat elsewhere | 0.1 | 0.31 | 0 | 1 |
| Rely on less expensive foods | 0.5 | 0.50 | 0 | 1 |
| Eliminate some components from a meal | 0.5 | 0.50 | 0 | 1 |
| Consume low-quality foods | 0.5 | 0.50 | 0 | 1 |
| Consume seed stock held for next season | 0.2 | 0.42 | 0 | 1 |
| Consume less preferred foods | 0.5 | 0.50 | 0 | 1 |
| Household head migrates to work | 0.1 | 0.34 | 0 | 1 |
| Make handicrafts to raise money for food | 0.1 | 0.32 | 0 | 1 |
| Perform an occasional job | 0.2 | 0.42 | 0 | 1 |
| Borrow food from a friend or relative | 0.2 | 0.37 | 0 | 1 |
| Purchase food on credit | 0.2 | 0.40 | 0 | 1 |
| Gather wild food, hunt, or harvest immature crops | 0.1 | 0.33 | 0 | 1 |
| Send household members to beg | 0.02 | 0.13 | 0 | 1 |
| Average number of coping mechanisms adopted | 4.5 | 3.74 | 0 | 16 |

The intensity of the coping strategies (i.e., the number of strategies) employed by the respondents is reported in Figure 20. About 23% of the respondents did not adopt any of the coping strategies to mitigate their food insecurity status. Recall that 34% of the sampled respondents were food secure under HFIAS, which could explain the high percentage of households who did not adopt any food insecurity coping mechanism. About 77% of the sampled farmers used either a single or multiple coping strategies. The proportion of households adopting more strategies begins to decrease from three coping strategies. It can be inferred that over one-third of the households engaged in less than the mean of 4.4 estimated in Section 7.3.

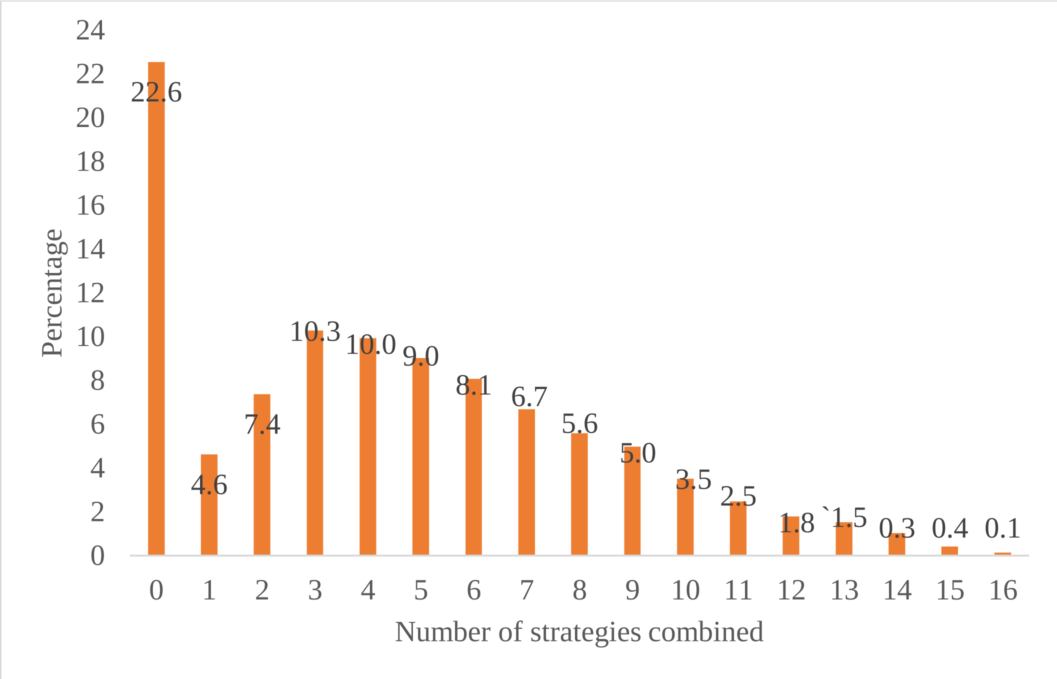



***Figure 20. Percentage distribution of the combinations of food insecurity coping strategies***

# CHAPTER 8: POVERTY

## 8.1 Income Distribution of Farmers

Table 34 shows the income profile of the sampled households. The average total household income of the sample was GHS 6,597, and this was mostly from crop income (GHS 5,218.66). The role of off-farm income in the well-being of farm households cannot be discounted, as this made the second highest contribution to household income. This, however, raises concern over resource (e.g., labor and time) maximization between crop and off-farm activities. The observed high crop income means that any sustained improvement in crop income will have a sustainable positive effect on household welfare. This is consistent with estimates that a growth in the agriculture sector contributes higher returns than other sectors to the economic growth of Ghana (Enu, 2014). Also, juxtaposing the average annual income with the average food consumption expenditure of GHS 6,915.3 per household implies that a farmer would spend virtually all income on providing food for their family. However, the total household food expenditure is not borne by only the interviewed individuals in the family; instead, many household members pool their incomes for the household expenditures. Therefore, it is too simplistic to compare the individual income in Table 33 with the household food expenditure in Table 29.

*Table 34. Descriptive statistics of income of farm households*

| Income Source | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Crop income | 1,450 | 5,218.7 | 7,714.3 | 42 | 89,400 |
| Livestock | 743 | 889.9 | 1,762.8 | 1 | 15,000 |
| Fishing | 170 | 199.4 | 443.5 | 2 | 4,000 |
| Off farm | 548 | 1,628.7 | 2,861.7 | 1 | 19,000 |
| Rent | 148 | 901.8 | 1,578.4 | 2 | 7,000 |
| Remittance | 255 | 506.7 | 624.8 | 1 | 4,000 |
| Aid | 41 | 177.1 | 349.1 | 2 | 2,100 |
| Government support | 108 | 335.5 | 409.3 | 1 | 1,600 |
| Dowry | 85 | 369.5 | 553.9 | 1 | 4,000 |
| Inheritance | 111 | 663.8 | 2,148.2 | 1 | 15,000 |
| Total[a] | 1,450 | 6,597.2 | 9,069.8 | 57 | 116,300 |

a. Weighted total.

## 8.2 Poverty Rate Among Households

Over the years, the north has continued to be the poorest part of Ghana (GSS, 2018). In this report, the poverty level of the farm households was determined using the Poverty Probability Index (PPI) approach. The PPI approach uses the consumption-based definition of poverty and involved asking households a set of 10 questions. An understanding of the poverty levels at this stage of the FERARI program is important to determine the proportion of households that are below the poverty line or are vulnerable to poverty, track the poverty levels over time, and measure the impact of FERARI activities on the well-being of the people. Table 35 reports the PPI of the sampled farmers based on gender and regional location.

The results indicate that about 55% of the sampled farmers were likely to live on less than US $1.25 per day. The difference in the PPI between males and females is marginal, but the lower incidence in females than males is consistent with Ghana’s poverty distribution (GSS, 2018). Regionally, the Northern, Savannah, and North East regions (formerly the Northern Region) had the highest PPI, while Bono East, Bono, and Ahafo regions (formerly Brong Ahafo region) had the lowest. The PPI of the various districts is presented in Figure 21, and this shows that poverty vulnerability is higher in East Mamprusi than in the other districts. The national data show that poverty incidence is about 61% in Northern Region and about 27% in Brong Ahafo Region (GSS, 2018). The high level of poverty in the study area justifies the need for the implementation of poverty-reducing programs that can significantly contribute toward an improvement in the welfare of Ghanaian farm households.

***Table 35. Mean statistics of poverty rate by gender and location***

| Category | Mean | Std. Dev. |
|---|---|---|
| ***Gender*** | | |
| Female | 54.3 | 26.2 |
| Male | 54.9 | 27.0 |
| Total | 54.8 | 26.9 |
| ***Region*** | | |
| Northern | 73.7 | 12.2 |
| North East | 73.9 | 18.2 |
| Savannah | 77.3 | 15.1 |
| Upper East | 56.0 | 20.2 |
| Upper West | 62.0 | 22.4 |
| Bono | 27.2 | 20.4 |
| Bono East | 26.1 | 18.3 |
| Ahafo | 42.9 | 19.9 |
| Total | 54.8 | 26.9 |

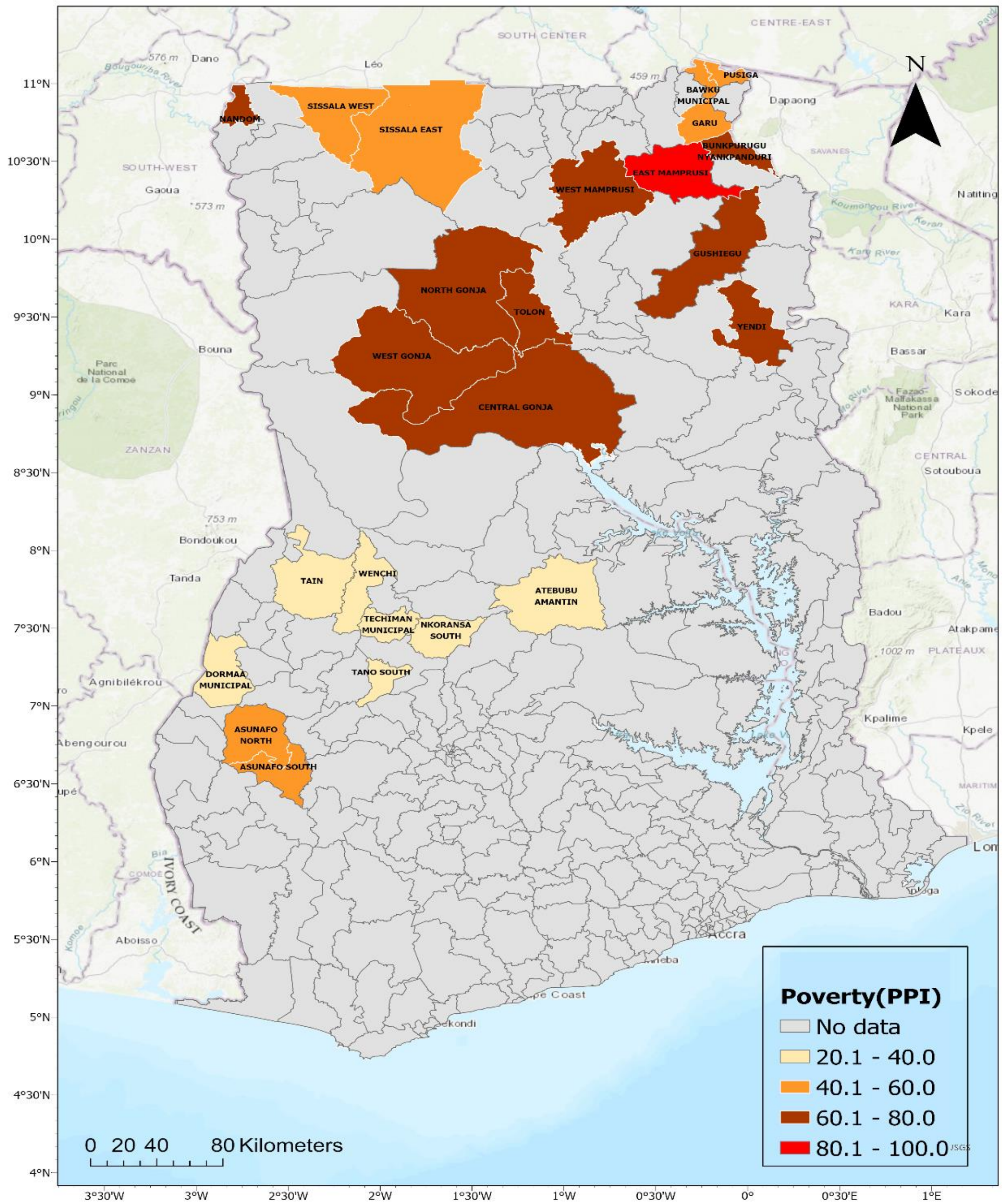



*Figure 21. Poverty map of selected districts*

# CHAPTER 9: EFFECT OF FERTILIZER APPLICATION ON KEY OUTCOMES

## 9.1 Introduction

This chapter details the impacts of the fertilizer types used by the farmers on key livelihood outcomes, such as yield and food security of the farm households.

## 9.2 Farmers' Perception of the Effect of Fertilizer Use on General Standard of Living

The farmers indicated whether fertilizer use had any effect on their standard of living. Only about 65.6% indicated that the use of fertilizer led to an improvement in their standard of living. Although this is a majority, more farmers were expected to recognize fertilizer as a major factor in improving their standard of living. For farmers who mentioned an effect of fertilizer on their standard of living, they indicated that this was mainly because the use of fertilizer had led to an increase in food sufficiency/availability, increase in income, ability to send wards to school, pay bills such as utility and health, and ability to acquire assets such as motorbikes, tricycles, and livestock. The key informant interviews also revealed divergent views, as some indicated that the use of fertilizer had improved their standard of living, while others indicated it had not. For instance, those who asserted a positive effect of fertilizer use on their standard of living expressed that "*Most of us can take care of our basic needs and take care of our children in school," "We are able to take care of some personal and family needs," "We are able to pay school fees, attend social functions like funerals, outdooring, and hospital bills, making life much easier,*" and *"On average, we are better off."*

On the other hand, farmers who indicated fertilizer had no effect on their standard of living mentioned that the use of fertilizer reduced their income for other activities. Others indicated that there was a lack of a market for their produce; hence, they could not sell their harvest even if fertilizer use increased their yields. A key informant noted the effect of fertilizer on his standard of living, saying that "*The standard of living in this community is the same as when we weren't using fertilizer. We spend what we get on farm inputs so there is nothing to save or spend on ourselves."* Another key informant indicated that "*Our standard of living is the same because we still use the money we get to purchase farm inputs."*

## 9.3 Effect of Fertilizer Use in Maize Production

### 9.3.1 *Fertilizer Use and Maize Yield*

The various fertilizer formulations used by farmers (Table 12) included NPK, NPK+Zn, NPK+S, NPK+Zn+S, NPK+Zn+S+Mg, NPK+S+Mg, and NPK+Zn+Mg. On average (Table 36), farmers used less than the recommended application rate of 90N-40$P_2O_5$-40$K_2O$-1.7Zn for maize production (https://feserwam.org/). Ragasa and Chapoto (2017) also found that farmers in the north of Ghana apply less (56 kg/ha) N to the crops.

For Ahafo Region, four fertilizer formulations were largely used. The use of NPK or NPK with S led to more than double the yield under no fertilizer application. However, the use of only urea did not improve yields in the region. The Bono Region also had higher yields when NPK was used with S. Use of NPK with Zn at a rate of 54.6-28.5-28.5-0.9 led to an approximately 0.5 mt/ha increase in yield over no fertilizer application in the region. Farmers who applied no fertilizer in Bono East Region had only a little over 0.5 mt/ha. However, the yield increased to about 2.7 mt/ha when farmers used NPK-Zn at an average rate of 125.5-60-60-1.2.

The yields of the Guinea Savannah zone were low except for farmers in Upper West Region. However, farmers who used any form of fertilizer formulation had higher yields than farmers who used no fertilizer. For instance, farmers in North East and Upper East regions who used NPK+Zn had about a 0.3 mt/ha higher yield than farmers who did not apply any fertilizer. Comparing the yields in the Transitional zone with those of the Savannah led to estimates consistent with Ragasa and Chapoto (2017), who reported that maize yields were lower in the northern savannah zone than in the southern zone.

*Table 36. Mean distribution of fertilizer use and maize yield*

| Fertilizer Formulation | % Obs. | Average Nutrient Rate (kg/ha) | | | | | | Apparent Nutrient (kg/ha) | Yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|
| | | N | $P_2O_5$ | $K_2O$ | Zn | S | MgO | | |
| **Ahafo** | | | | | | | | | |
| Non-users | 88.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,158.3 |
| NPK | 7.5 | 53.1 | 32.6 | 32.6 | 0 | 0 | 0 | 118.2 | 2,599 |
| NPK+S | 1.3 | 56.9 | 28.8 | 28.8 | 0 | 21 | 0 | 135.4 | 2,500 |
| N | 0.6 | 50 | 0 | 0 | 0 | 0 | 0 | 50 | 1,000 |
| NS | 1.9 | 62.5 | 0 | 0 | 0 | 47 | 0 | 109.5 | 1,861.1 |
| **Bono** | | | | | | | | | |
| Non-users | 20.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,464 |
| NPK | 34.5 | 56.9 | 25.3 | 25.3 | 0 | 0 | 0 | 107.6 | 1,575.5 |
| NPK+S | 1.7 | 93.7 | 33.3 | 33.3 | 0 | 35.5 | 0 | 195.8 | 2,288.9 |
| NPK+S+MgO | 5.1 | 56.2 | 21.5 | 21.5 | 0 | 10 | 0.5 | 109.6 | 2,111.4 |
| NPK+Zn | 8.5 | 54.6 | 28.5 | 28.5 | 0.9 | 0 | 0 | 112.5 | 2,018.1 |
| NPK+Zn+MgO | 3.4 | 74 | 27.5 | 26.7 | 1.9 | 0 | 5.1 | 135.2 | 2,016.9 |
| NPK+Zn+S | 1.7 | 50 | 24.2 | 24.2 | 0.8 | 10 | 0 | 109.3 | 1,766.7 |
| N | 20.9 | 63.5 | 0 | 0 | 0 | 0 | 0 | 63.5 | 1,647.4 |
| NS | 3.4 | 50.5 | 0 | 0 | 0 | 11.7 | 0.0n | 62.2 | 1,758.3 |
| **Bono East** | | | | | | | | | |
| Non-users | 0.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 625 |
| NPK | 21.7 | 62.4 | 26.3 | 26.3 | 0 | 0 | 0 | 115.1 | 1,445.8 |
| NPK+S | 11.2 | 81 | 29.3 | 29.3 | 0 | 33.6 | 0 | 173.2 | 1,468.8 |
| NPK+S+MgO | 5.3 | 67.9 | 25.8 | 25.8 | 0 | 11.1 | 0.5 | 131.1 | 1,677.1 |
| NPK+Zn | 2.0 | 125.5 | 60 | 60 | 1.2 | 0 | 0 | 246.7 | 2,713 |
| NPK+Zn+MgO | 24.3 | 77 | 24.3 | 20.5 | 1.8 | 0 | 5.7 | 129.3 | 1,525.3 |
| NPK+Zn+S+MgO | 28.3 | 106.8 | 31.8 | 28.8 | 1.7 | 27.9 | 5.1 | 202.1 | 1,545.8 |
| N | 4.6 | 84.8 | 0 | 0 | 0 | 0 | 0 | 84.8 | 1,347.6 |
| NS | 2.0 | 56.7 | 0 | 0 | 0 | 29.2 | 0 | 85.8 | 1,555.6 |

| Fertilizer Formulation | % Obs. | Average Nutrient Rate (kg/ha) | | | | | | Apparent Nutrient (kg/ha) | Yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|
| | | N | $P_2O_5$ | $K_2O$ | Zn | S | MgO | | |
| **North East** | | | | | | | | | |
| Non-users | 11.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,010.4 |
| NPK | 13.3 | 61 | 32.9 | 32.9 | 0 | 0 | 0 | 126.8 | 1,462.3 |
| NPK+S | 12.2 | 62.9 | 25.4 | 25.4 | 0 | 27.6 | 0 | 141.3 | 1,415 |
| NPK+S+MgO | 7.2 | 73.2 | 33 | 33 | 0 | 12.7 | 0.7 | 152.6 | 1,558.3 |
| NPK+Zn | 35.4 | 54.3 | 40.2 | 40.2 | 1.3 | 0 | 0 | 136 | 1,343 |
| NPK+Zn+MgO | 1.7 | 93.1 | 38.8 | 25.8 | 2 | 0 | 7.5 | 167.2 | 1,891.7 |
| NPK+Zn+S | 12.2 | 56.4 | 30.4 | 30.4 | 0.9 | 19.4 | 0 | 137.5 | 1,368.4 |
| NPK+Zn+S+MgO | 4.4 | 57.7 | 28.2 | 26.8 | 1.3 | 17.9 | 2.9 | 134.7 | 1,474 |
| N | 0.6 | 143.8 | 0 | 0 | 0 | 0 | 0 | 143.8 | 1,562.5 |
| NS | 2.2 | 53.2 | 0 | 0 | 0 | 30 | 0 | 83.2 | 1,135.4 |
| **Northern** | | | | | | | | | |
| Non-users | 11.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,117.1 |
| NPK | 13.9 | 62.1 | 26.4 | 26.4 | 0 | 0 | 0 | 114.8 | 1,287.2 |
| NPK+S | 6.9 | 51.6 | 21.7 | 21.7 | 0 | 24.4 | 0 | 119.4 | 1,230.6 |
| NPK+S+MgO | 2.9 | 57.4 | 22 | 22 | 0 | 17.6 | 0.5 | 119.5 | 1,460.7 |
| NPK+Zn | 9.8 | 54.5 | 36.3 | 36.3 | 1.2 | 0 | 0 | 128.3 | 1,306.1 |
| NPK+Zn+MgO | 39.9 | 59.7 | 25.4 | 22.1 | 1.9 | 0 | 5.2 | 114.2 | 1,192.5 |
| NPK+Zn+S | 2.9 | 74.4 | 25.8 | 25.8 | 0.8 | 35.2 | 0 | 162 | 1,087.5 |
| NPK+Zn+S+MgO | 6.9 | 90.6 | 35.4 | 31 | 1.7 | 25.4 | 4.5 | 188.6 | 1,314.6 |
| N | 2.3 | 61.5 | 0 | 0 | 0 | 0 | 0 | 61.5 | 1,166.7 |
| NS | 3.5 | 52 | 0 | 0 | 0 | 29.4 | 0 | 81.4 | 1,053.6 |
| **Savannah** | | | | | | | | | |
| Non-users | 29.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 840 |
| NPK | 17.0 | 54.4 | 23.3 | 23.3 | 0 | 0 | 0 | 101 | 1,043.8 |
| NPK+S | 13.6 | 50 | 20.4 | 20.4 | 0 | 18.3 | 0 | 109.2 | 1,085.3 |
| NPK+S+MgO | 1.7 | 66.7 | 30 | 30 | 0 | 10 | 0.7 | 137.3 | 1,666.7 |
| NPK+Zn | 24.4 | 50.9 | 27.4 | 27.4 | 0.7 | 0 | 0 | 106.4 | 1,083.6 |
| NPK+Zn+MgO | 0.6 | 50 | 20 | 20 | 1.7 | 0 | 3.3 | 95 | 1,000 |
| NPK+Zn+S | 1.7 | 54.8 | 33.3 | 33.3 | 0.9 | 15 | 0 | 137.3 | 1,229.2 |
| NPK+Zn+S+MgO | 0.6 | 66 | 20 | 20 | 2 | 36 | 6 | 150 | 1,100 |
| N | 2.3 | 51.9 | 0 | 0 | 0 | 0 | 0 | 51.9 | 1,140.6 |
| NS | 8.5 | 53 | 0 | 0 | 0 | 22.2 | 0 | 75.2 | 1,090.3 |
| **Upper East** | | | | | | | | | |
| Non-users | 2.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 812.5 |
| NPK | 16.6 | 80.6 | 36.1 | 36.1 | 0 | 0 | 0 | 152.7 | 1,059.9 |
| NPK+S | 1.2 | 81.3 | 37.5 | 37.5 | 0 | 50 | 0 | 206.3 | 1,125 |
| NPK+S+MgO | 5.3 | 69.4 | 28.3 | 28.3 | 0 | 10 | 0.6 | 136.6 | 1,027.8 |
| NPK+Zn | 52.1 | 70.2 | 47.3 | 47.3 | 1.6 | 0 | 0 | 166.3 | 1,143.1 |
| NPK+Zn+MgO | 13.0 | 88.1 | 36.4 | 32.1 | 1.8 | 0 | 5.2 | 163.6 | 1,022.7 |
| NPK+Zn+S | 4.1 | 94.3 | 48 | 48 | 1.5 | 30.7 | 0 | 222.6 | 1,125 |
| NPK+Zn+S+MgO | 4.7 | 105.6 | 39.6 | 33.6 | 1.5 | 18.9 | 3.4 | 202.7 | 1,093.8 |
| NS | 0.6 | 50 | 0 | 0 | 0 | 30 | 0 | 80 | 1,000 |

| Fertilizer Formulation | % Obs. | Average Nutrient Rate (kg/ha) | | | | | | Apparent Nutrient (kg/ha) | Yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|
| | | N | $P_2O_5$ | $K_2O$ | Zn | S | MgO | | |
| **Upper West** | | | | | | | | | |
| Non-users | 2.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,437.5 |
| NPK | 31.3 | 76.2 | 40.9 | 40.9 | 0 | 0 | 0 | 157.9 | 2,251.5 |
| NPK+S | 51.1 | 84.1 | 36.2 | 36.2 | 0 | 28.7 | 0 | 185.2 | 2,408.8 |
| NPK+S+MgO | 10.8 | 93.9 | 35.8 | 35.8 | 0 | 22.1 | 0.7 | 188.3 | 2,737.7 |
| NPK+Zn+MgO | 1.1 | 109.5 | 40 | 25.6 | 2 | 0 | 7.5 | 184.6 | 2,312.5 |
| NPK+Zn+S+MgO | 0.6 | 66 | 20 | 20 | 2 | 36 | 6 | 150 | 1,000 |
| N | 0.6 | 86.3 | 0 | 0 | 0 | 0 | 0 | 86.3 | 1,875 |
| NS | 2.3 | 59.9 | 0 | 0 | 0 | 23.8 | 0 | 83.6 | 1,031.3 |

*Note: Number of observations: Northern=173; North East=181; Savannah=176; Upper East=169; Upper West=176; Bono=177; Bono East=152; and Ahafo=159*

### 9.3.2 *Drivers of Fertilizer Use Among Maize Farmers*

The factors that influenced farmers' use of fertilizer are shown in Table 37. The definitions of variables are provided in Appendix 2. Tobit regression was used to account for the non-use of fertilizer by some of the farmers. The results show that factors, such as socioeconomics, welfare, labor, perception, and location, had a significant effect on the decision to use fertilizer and at what intensity for maize production.

Youth had a significant positive effect on the use of fertilizer. This implies that farmers under 36 years of age are more like to use fertilizer and apply a higher quantity of fertilizer than farmers over the age of 35. Generally, youths are not only energetic but are early adopters of new technologies. Therefore, the youths are able to provide the needed labor for fertilizer application. This finding justifies the call for policies that promote youths in agriculture.

Extension had a positive effect on the use of fertilizer, as farmers who received extension services used more fertilizer than farmers who did not receive extension services. Generally, extension officers provide advice to farmers and link them with input dealers. This can improve the farmers' use of fertilizer in maize production. Wiredu et al. (2015) explained that effective extension services are vital for promoting specific fertilizer combinations. Access to credit also had a positive effect on fertilizer use. This is consistent with the farmers' ranking of a lack of credit as a prime challenge to fertilizer use (Table 14) and the results shown in Table 27 in which lack of funds was mentioned as one of the major reasons for not using fertilizer.

The cultivation of improved maize seeds led to intense fertilizer use. The results indicate that farmers who planted improved maize seeds used more fertilizer than those who used local or traditional seeds. This was expected since the promotion of improved seeds always includes the promotion of fertilizer use in order to obtain maximum yield from such seeds. For instance, under the PFJ program, both fertilizer and improved seed are subsidized at the same rate, which suggests a complementary effect of these two inputs. Ragasa and Chapoto (2017) explained that understanding and resolving low access to complementary inputs, such as seeds, can enhance the use of fertilizer.

Ownership of farmland enhanced the use of fertilizer. Farmers who cultivated maize on their own lands used more fertilizer than farmers who cultivated maize under other land tenure systems, such as rented or communal lands. This is because farmers who cultivated their own land have knowledge of their fertility status and how the lands have been cultivated in the past. With such information, they are able to intensify their use of fertilizer.

The effect of distance from farmers' home to input shops on fertilizer use intensity was negative, an indication that farmers who are far from input shops used little fertilizer in maize production. This is due to the farmers inability to reach the fertilizers or the farmers' need to balance their limited budget between transportation cost and fertilizer cost. Recall from Table 28 that unavailability was one of the major reasons for not using fertilizer for maize production. These findings justify the need for easing access to fertilizer for farmers.

Family labor and hired labor had a positive effect on fertilizer use intensity. However, only hired labor was statistically significant in explaining the variations in fertilizer use intensity by the farmers. Thus, farmers who used more hired labor in maize production used more fertilizer than those who used less or no hired labor. Fertilizer application is labor intensive and, therefore, farmers who do not have access to or cannot afford the cost of labor may apply little or no fertilizer to their crop. A similar result was obtained by Ragasa and Chapoto (2017). Wiredu et al. (2015) also estimated that a higher labor-to-land ratio leads to intensive use of fertilizer in Ghana.

Three welfare measures were considered in explaining the fertilizer use of farmers. The results indicate that PPI and per capita food consumption expenditure had a significantly negative effect on fertilizer use, while the effect of non-farm income was statistically insignificant. This means that the higher the probability of a farmer becoming poor and the higher the expenditure on food consumption, the lower the amount of fertilizer used by the farmer. Capital investment in farming by the poor is often hindered by their inability and not necessarily by their unwillingness. Therefore, farmers who do not have enough money or spend high amounts on food consumption may have little capital reserved for farm investment, especially for buying complementary inputs, such as fertilizer. Although insignificant in this study, Wiredu et al. (2015) estimated that engaging in non-farm activities significantly increases fertilizer use intensity.

Farmers' perception on their farmland's fertility status had implications on their fertilizer use decisions or intensity. Farmers who perceived their soils to be very fertile (obtaining maximum yield without fertilizer application) used less fertilizer on their farms than those who perceived their soils to be less fertile. Since inorganic fertilizer is a complement to the fertility content of the soils and as rational decision makers, farmers who perceive their soils to be fertile would not be willing to buy more fertilizer. Ragasa and Chapoto (2017) also found that farmers who perceive their soils to be moderately or very fertile are less likely to use fertilizer.

The regional location of the farmers had a significant effect on their use of fertilizer. However, the direction of the effect differs by region. Specifically, farmers located in Savannah, Bono, and Ahafo regions used less fertilizer than farmers in Northern Region. On the other hand, farmers in Upper East, Upper West, Bono East, and Ahafo regions used significantly more fertilizer than farmers in Northern Region. This is consistent with Dogor et al. (2020), which shows that Northern Region received larger quantities of fertilizer under the PFJ program than Savannah, Ahafo, and Bono regions but lower quantities than Upper West, Upper East, and Bono East regions.

*Table 37. Estimates of fertilizer application rates among maize farmers*

| Variable | Coeff. | Std. Err. | P value |
|---|---|---|---|
| Gender | 0.13 | 5.35 | 0.981 |
| Youth | 13.19** | 5.26 | 0.012 |
| Extension | 8.41** | 4.11 | 0.041 |
| Credit access | 14.53*** | 5.33 | 0.006 |
| FBO | 1.54 | 4.80 | 0.749 |
| Education | 0.71 | 0.44 | 0.105 |
| Experience | -0.02 | 0.20 | 0.927 |
| Leadership position | -2.22 | 4.69 | 0.636 |
| Distance from home to input shop | -0.08*** | 0.02 | 0.000 |
| Ownership of mobile phone | 9.10 | 8.47 | 0.283 |
| Ownership of farmland | 11.19** | 4.35 | 0.010 |
| Improved seed | 23.81*** | 6.06 | 0.000 |
| Farm size | -0.14 | 0.34 | 0.690 |
| Hired labor | 0.89*** | 0.16 | 0.000 |
| Family labor | 0.36 | 0.45 | 0.423 |
| Non-crop income | 0.00 | 0.00 | 0.911 |
| PPI | -0.27** | 0.11 | 0.012 |
| Food consumption expenditure | -0.001 | 0.002 | 0.645 |
| **Perception of soil fertility (reference is less fertile):** | | | |
| Very fertile | -46.96*** | 8.40 | 0.000 |
| Fertile | -1.40 | 4.35 | 0.748 |
| **Region (reference is Northern Region):** | | | |
| North East | 8.56 | 7.81 | 0.273 |
| Savannah | -31.92*** | 8.03 | 0.000 |
| Upper East | 53.22*** | 8.31 | 0.000 |
| Upper West | 66.95*** | 8.02 | 0.000 |
| Bono | -38.80*** | 10.12 | 0.000 |
| Bono East | 30.65*** | 10.06 | 0.002 |
| Ahafo | -155.93*** | 11.33 | 0.000 |
| Constant | 92.90 | 15.52 | 0.000 |
| Lambda | 65.03 | 1.45 | |

*Note: *** and ** indicate significance at 1% and 5%, respectively.*

*Dependent variable: Intensity of fertilizer nutrient applied (kg/ha).*

### 9.3.3 *Effect of Fertilizer Application on Maize Production*

Table 38 shows the correlation matrix among the various fertilizer nutrients. There was a positive correlation among all nutrients. Thus, the nutrients are complementary: increasing one nutrient may require that the other be increased as well. However, the correlations between S and P and

Mg and K were not statistically significant. The graphical distribution of the nutrients as well as the nutrient formulations and yield are shown in Appendices 4 and 5.

*Table 38. Correlation matrix for fertilizer nutrients*

| * | N | P | K | Zn | S | Mg |
|---|---|---|---|---|---|---|
| N | 1 | | | | | |
| P | 0.80*** | 1 | | | | |
| K | 0.67*** | 0.90*** | 1 | | | |
| Zn | 0.30*** | 0.36*** | 0.28*** | 1 | | |
| S | 0.29*** | 0.03 | 0.08* | 0.19*** | 1 | |
| Mg | 0.38*** | 0.31*** | 0.05 | 0.98*** | 0.52*** | 1 |

*Note: *** and * indicate significance at 1% and 10%, respectively.*

Table 39 shows the effects of fertilizer application and other variables on maize yield. These variables are defined in Appendix 2. This involved the estimation of a stochastic frontier model (SFA), which fundamentally assumes that farmers operate within a production frontier and the level of the frontier; the position of the farmer below or on the frontier is determined by a set of factors within and outside the control of the farmers. Two models were estimated. In Model 1, it was assumed that there were no inefficiency factors explaining maize yield difference, while in Model 2, this assumption was collapsed. The return to scale (RTS) in both models indicates that there is a less than proportional increase in output if all inputs are increased. In Model 2, for instance, a 100% increase in all inputs resulted in about an 84% increase in output. Oppong et al. (2016) also estimated a decreasing RTS for maize farmers in Brong-Ahafo Region to be 80%.

The results show that improved seeds had a significant positive effect on maize yield, although insignificant in Model 2. Thus, the higher the quantity of improved seed used, the higher the output. Similarly, local seeds had a positive effect on maize yield, and this was significant in both models. The implication is that the farmers must increase the quantity of improved or local seeds planted per farm area, thus increasing plant densities, in order to increase maize yield. This is consistent with the results in Table 5 that suggest that the farmers were planting less than the recommended seed rates. Martey et al. (2019) had a similar finding.

Hired labor had a significant positive effect on maize yield. The estimate of Model 2, for instance, suggests that additional hired labor (number of workers per hectare) would result in about a 0.03 kg/ha increase in maize yield. Access to labor is a major factor in determining how and when agronomic practices are performed. Farmers with high access to labor may be able to perform the needed practices, such as weeding, on time.

The use of herbicides led to an increase in maize yield. Weed management is an important factor in crop production. Therefore, using herbicides eases the burden of manual weeding, which requires longer working days and more labor. Using herbicides also allows the farmers to effectively control their farm weeds. Wongnaa and Awunyo-Vitor (2018) and Oppong et al. (2016) also estimated a positive effect of herbicides on maize yield.

All of the fertilizer formulations had a significant positive effect on maize yield. An increase in the use of these fertilizers led to an increase in maize yield. However, the elasticity of these fertilizer formulations varies. Generally, the percentage increase in maize yield was the highest with an increase in the quantity of NPK+S fertilizers and lowest with an increase in the quantity of NPK+Zn fertilizer among all nutrient combinations. Model 2 shows a 100% increase in NPK+S led to an 11.6% increase in maize yield, while a 100% increase in NPK+Zn led to a 5.3% increase. This is consistent with the results in Table 36, which show that the NPK+S fertilizer users had higher yields than the users of other fertilizer formulations in most of the regions. Overall, there is the need for farmers to increase the use of the various fertilizers, as they lead to an increase in maize yield. Empirically, Martey et al. (2019) also estimated a positive effect of fertilizer on maize yield, while Wongnaa and Awunyo-Vitor (2018) estimated that Ghanaian farmers who use fertilizer in maize production are more efficient in maize production than non-fertilizer users.

The inefficiency model showed that only education, extension, PPI, and perception of soil fertility had a significant effect in explaining the efficiency of maize farmers. It is important to note that the dependent variable in the second component of the stochastic frontier model is inefficiency: a negative coefficient of an explanatory variable means an increase in the variable, leading to a decrease in inefficiency, hence an increase in efficiency, and vice versa. All except PPI had a negative effect on technical inefficiency. The results imply that farmers who had more formal education, accessed extension services, perceived their soil to be fertile, and were less likely to be poor were more efficient in maize production. Formal education helps farmers to search for knowledge about their farms, while extension officers also provide technical advice and link farmers to input suppliers. These are expected to enhance the farmers' production efficiency. The effects of education and extension access are consistent with the result of Anang et al. (2020). Wongnaa and Awunyo-Vitor (2018) explained that education improves human capital, which is essential for improving the managerial and technical skills of farmers. Similarly, farmers who are less likely to be poor may invest more capital resources in their farms, thereby improving their efficiencies. The mere fact that a farmer perceived his/her farmland to be fertile would influence their adoption of appropriate strategies in anticipation of higher yields. The descriptive statistics also show that farmers who perceived their farmland to be fertile or very fertile had an average output of about 1.5 mt/ha, while those who perceived their farmland to be less fertile had an average yield of about 1.4 mt/ha.

Practically, the coefficients can be explained in terms of actual yields by taking the antilog of the estimated coefficients. For instance, the 0.022 estimated coefficient of improved seeds means that an additional 1 kg/ha of improved seed would lead to an increase in yield of 1.1 kg/ha ($10^{0.022}$). Similarly, an additional 1 kg/ha of NPK would lead to an increase in yield by 1.2 kg/ha ($10^{0.083}$).

*Table 39. Effects of fertilizer application on maize yield*

| Variable | Model 1 Coeff. | Model 1 Std. Err. | Model 1 P-Value | Model 2 Coeff. | Model 2 Std. Err. | Model 2 P-Value |
|---|---|---|---|---|---|---|
| **Output model** | | | | | | |
| Farm size | -0.011 | 0.024 | 0.664 | -0.012 | 0.027 | 0.661 |
| Improved seeds | 0.022* | 0.012 | 0.064 | 0.005 | 0.014 | 0.692 |
| Local seeds | 0.014* | 0.008 | 0.087 | 0.022** | 0.009 | 0.012 |
| Herbicides | 0.103*** | 0.014 | 0.000 | 0.097*** | 0.014 | 0.000 |
| Family labor | -0.003 | 0.017 | 0.853 | 0.016 | 0.017 | 0.327 |
| Hired labor | 0.036*** | 0.011 | 0.001 | 0.030*** | 0.011 | 0.009 |
| NPK | 0.083*** | 0.007 | 0.000 | 0.084*** | 0.007 | 0.000 |
| NPK-Zn | 0.048*** | 0.008 | 0.000 | 0.053*** | 0.008 | 0.000 |
| NPK-S | 0.113*** | 0.008 | 0.000 | 0.116*** | 0.008 | 0.000 |
| NPK-Zn-S | 0.050*** | 0.014 | 0.000 | 0.056*** | 0.014 | 0.000 |
| NPK-Zn-S-Mg | 0.059*** | 0.010 | 0.000 | 0.057*** | 0.010 | 0.000 |
| NPK-S-Mg | 0.117*** | 0.011 | 0.000 | 0.115*** | 0.011 | 0.000 |
| NPK-Zn-Mg | 0.053*** | 0.009 | 0.000 | 0.055*** | 0.009 | 0.000 |
| NS | 0.053*** | 0.015 | 0.001 | 0.057*** | 0.015 | 0.000 |
| N | 0.088*** | 0.014 | 0.000 | 0.084*** | 0.014 | 0.000 |
| Constant | 6.661 | 0.126 | 0.000 | 6.706 | 0.055 | 0.000 |
| *RTS* | *0.825* | | | *0.835* | | |
| **Inefficiency model** | | | | | | |
| Youth | | | | 0.041 | 0.631 | 0.948 |
| Gender | | | | 0.380 | 0.596 | 0.524 |
| Education | | | | -0.298* | 0.158 | 0.059 |
| FBO | | | | -0.267 | 0.609 | 0.662 |
| Experience | | | | 0.011 | 0.020 | 0.597 |
| Smallholder farmer | | | | -0.500 | 0.609 | 0.412 |
| Distance from home to input shop | | | | 0.001 | 0.002 | 0.552 |
| Extension | | | | -0.969* | 0.561 | 0.084 |
| Credit access | | | | 0.448 | 0.576 | 0.437 |
| Mixed cropping | | | | -0.048 | 0.468 | 0.919 |
| Improved seed | | | | -2.243 | 2.341 | 0.338 |
| PPI | | | | 0.029* | 0.015 | 0.059 |
| **Soil fertility (reference is less fertile):** | | | | | | |
| Very fertile soil | | | | -29.204 | 1638.893 | 0.986 |
| Fertile soil | | | | -0.795* | 0.441 | 0.072 |
| Constant | | | | -4.858 | 1.896 | 0.010 |
| **Variance parameters** | | | | | | |
| $lnsig^2v$ | -1.841*** | 0.038 | 0.000 | 0.040 | 0.000 | |
| sigma_v | 0.398 | 0.008 | | 0.386 | 0.008 | |
| $lnsig^2u$ | -11.490 | 89.355 | 0.898 | | | |
| lambda | 0.008 | 0.144 | | | | |
| Wald Chi sq. | 382.15*** | | | 369.75*** | | |

*Note: ***, **, and * indicate significance at 1%, 5%, and 10%, respectively.*

Table 40 shows an OLS regression of the effect of specific nutrients on maize yield. This is different from Table 39, which examined the effect of the various nutrient formulations on maize yield. From Model 1, in which production inputs excluding fertilizer were used, farm size had a significant positive effect on maize yield, contrary to the result in Table 39. From Model 2, which only looked at the effect of nutrients, N, P, and S had a significant positive effect on maize yield, while Zn had a significant negative effect on maize yield. This is similar to the result in Model 3, which considers all variables, except that P is insignificant. The implication is that more N and S are particularly important in increasing maize yields in the regions. Overall, the negative effect of Zn on yield requires further investigation, especially from experimental data. Although improved seeds had an insignificant effect on maize yield in Model 1, the effect was significant in Model 3. This could mean that the effect of improved seeds on maize yields become significant if they are used with fertilizers. Similarly, comparing the results of Models 1 and 3 shows that the effect of improved seeds increases over the effect of local seeds on yield only if fertilizers are applied.

A similar model but with a stochastic frontier specification was estimated, and the results are shown in Appendix 3. This confirms that local seeds, herbicides, and hired labor have a significant positive significant effect on maize yield. Among the fertilizer nutrients, more N and S and less Zn are needed to significantly increase maize yield. For the efficiency-explaining factors, higher formal education, access to extension, lower PPI, and perception of farmland as fertile significantly enhance farmers' efficiency of maize production.

*Table 40. Maize yield and fertilizer nutrient*

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| **Variable** | **Coeff.** | **Std. Err.** | **Coeff.** | **Std. Err.** | **Coeff.** | **Std. Err.** |
| Farm size | 0.057** | 0.026 | | | -0.017 | 0.025 |
| Improved seed | 0.018 | 0.013 | | | 0.020* | 0.012 |
| Local seed | 0.028*** | 0.009 | | | 0.014 | 0.008 |
| Herbicides | 0.102*** | 0.015 | | | 0.105*** | 0.014 |
| Family labor | 0.010 | 0.018 | | | -0.004 | 0.017 |
| Hired labor | 0.036*** | 0.012 | | | 0.038*** | 0.011 |
| Nitrogen | | | 0.061*** | 0.012 | 0.059*** | 0.012 |
| Phosphorus | | | 0.295* | 0.168 | 0.265 | 0.163 |
| Potassium | | | -0.243 | 0.167 | -0.209 | 0.163 |
| Zinc | | | -0.259*** | 0.038 | -0.258*** | 0.039 |
| Sulphur | | | 0.026*** | 0.009 | 0.027*** | 0.009 |
| Magnesium | | | 0.038 | 0.027 | 0.029 | 0.027 |
| Constant | 6.836 | 0.056 | 6.874 | 0.024 | 6.660 | 0.053 |

*Note: ***, **, and * indicate significance at 1%, 5%, and 10%, respectively*

## 9.4 Effect of Fertilizer Use in Rice Production

### 9.4.1 *Fertilizer Use and Rice Yield*

Table 41 shows the nutrient composition of the various fertilizers (Table 13) used by rice farmers as well as their associated yield. This shows that the average rice farmer did not apply most of the fertilizer types at their recommended rates of 100N-40$P_2O_5$-40$K_2O$-1.7Zn or 90N-60$P_2O_5$-60$K_2O$-0.5Zn (https://feserwam.org/). The use of fertilizer made a significant impact on the yield of rice for most regions, especially North East and Northern. For instance, farmers in North East Region who applied no fertilizer had less than 1 mt/ha of rice, while those who applied NPK+Zn had about 3.3 mt/ha.

*Table 41. Mean distribution of fertilizer use and maize yield*

| Fertilizer Formulation | % Obs | Average Nutrient Rate (kg/ha) N | P | K | Zn | S | Mg | Apparent Nutrient (kg/ha) | Yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|
| **Ahafo** | | | | | | | | | |
| Non-users | 64.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,108.8 |
| N | 8.9 | 56.6 | 0 | 0 | 0 | 0 | 0 | 56.6 | 3,558.3 |
| NPK | 13.3 | 52.1 | 24.2 | 24.2 | 0 | 0 | 0 | 100.4 | 3,604.2 |
| NPK+S | 11.1 | 62.7 | 27.5 | 27.5 | 0 | 20.9 | 0 | 138.7 | 2,925 |
| NS | 2.2 | 50 | 0 | 0 | 0 | 45 | 0 | 95 | 1,250 |
| **Bono** | | | | | | | | | |
| NPK+Zn+MgO | 100.0 | 100 | 40 | 40 | 2.5 | 0 | 0.9 | 183.4 | 1,833.3 |
| **Bono East** | | | | | | | | | |
| NPK | 6.7 | 100 | 40 | 40 | 0 | 0 | 0 | 180 | 1,500 |
| NPK+S | 40.0 | 82.2 | 31.3 | 31.3 | 0 | 48.9 | 0 | 193.6 | 1,631.9 |
| NPK+Zn | 13.3 | 88.2 | 40 | 40 | 0.9 | 0 | 0 | 169.1 | 1,250 |
| NPK+Zn+MgO | 13.3 | 86.4 | 34.6 | 24.1 | 2.5 | 0 | 7.5 | 155.1 | 1,125 |
| NPK+Zn+S+MgO | 26.7 | 100 | 27 | 25 | 1.8 | 35 | 4.3 | 193.1 | 1,500 |
| **North East** | | | | | | | | | |
| Non-users | 5.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 916.7 |
| NPK | 16.7 | 55.8 | 27.9 | 27.9 | 0 | 0 | 0 | 111.6 | 2,000 |
| NPK+S | 11.1 | 100 | 32.5 | 32.5 | 0 | 42.5 | 0 | 207.5 | 2,875 |
| NPK+S+MgO | 5.6 | 66.7 | 40 | 40 | 0 | 10 | 0.2 | 156.8 | 3,333.3 |
| NPK+Zn | 22.2 | 50 | 27.1 | 27.1 | 0.9 | 0 | 0 | 105.1 | 3,322.9 |
| NPK+Zn+S | 16.7 | 54.8 | 33.3 | 33.3 | 1.3 | 20.8 | 0 | 143.6 | 4,023.8 |
| NPK+Zn+S+MgO | 16.7 | 61 | 28.3 | 28.3 | 1.1 | 20.1 | 2 | 140.9 | 2,111.1 |
| NS | 5.6 | 50 | 0 | 0 | 0 | 10 | 0 | 60 | 3,000 |
| **Northern** | | | | | | | | | |
| Non-users | 15.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 916.7 |
| NPK | 20.5 | 63 | 28.6 | 28.6 | 0 | 0 | 0 | 120.2 | 1,785.7 |
| NPK+S+MgO | 4.5 | 68.6 | 24.3 | 24.3 | 0 | 29 | 0.4 | 146.6 | 2,114.6 |
| NPK+Zn | 6.8 | 62.6 | 35 | 35 | 1.7 | 0 | 0 | 134.3 | 2,833.3 |
| NPK+Zn+ MgO | 31.8 | 67.5 | 29.9 | 25.4 | 2.4 | 0 | 5.6 | 130.7 | 1,756.5 |
| NPK+Zn+S+MgO | 13.6 | 84.8 | 32.9 | 30.1 | 1.9 | 22.7 | 3.5 | 175.9 | 1,710.1 |
| NS | 6.8 | 54 | 0 | 0 | 0 | 31.8 | 0 | 85.8 | 1,187.5 |
| **Savannah** | | | | | | | | | |
| Non-users | 41.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,025.5 |
| NPK | 17.4 | 62.5 | 24.4 | 24.4 | 0 | 0 | 0 | 111.4 | 1,276 |
| NPK+S | 4.3 | 50 | 20 | 20 | 0 | 17 | 0 | 107 | 2,000 |
| NPK+S+MgO | 2.2 | 100 | 40 | 40 | 0 | 10 | 1 | 191 | 1,666.7 |
| NPK+Zn | 17.4 | 52.7 | 25.8 | 25.8 | 0.7 | 0 | 0 | 105 | 1,385.4 |
| NPK+Zn+S | 4.3 | 57.2 | 30 | 30 | 1.3 | 15 | 0 | 133.4 | 1,489.6 |
| NPK+Zn+S+MgO | 2.2 | 66 | 20 | 20 | 2.5 | 36 | 6 | 150.5 | 1,250 |
| NS | 8.7 | 52.8 | 0 | 0 | 0 | 25.9 | 0 | 78.8 | 2,187.5 |
| N | 2.2 | 50 | 0 | 0 | 0 | 0 | 0 | 50 | 1,000 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Upper East** | | | | | | | | | |
| Non-users | 3.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,250 |
| NPK | 27.3 | 74.1 | 31.8 | 31.8 | 0 | 0 | 0 | 137.6 | 3,400 |
| NPK+S | 1.8 | 99.4 | 40 | 40 | 0 | 60 | 0 | 239.4 | 1,000 |
| NPK+S+MgO | 5.5 | 66.7 | 26.7 | 26.7 | 0 | 10 | 0.4 | 130.4 | 1,666.7 |
| NPK+Zn | 45.5 | 73.5 | 39.2 | 39.2 | 2.2 | 0 | 0 | 154.2 | 2,006.7 |
| NPK+Zn+MoG | 9.1 | 95 | 36.4 | 35.2 | 2.3 | 0 | 5.9 | 174.8 | 1,950 |
| NPK+Zn+S | 1.8 | 50 | 21.9 | 21.9 | 0.4 | 10 | 0 | 104.2 | 4,000 |
| NPK+Zn+S+MgO | 5.5 | 100 | 40 | 35 | 2.3 | 26.7 | 3.1 | 207 | 2,500 |
| **Upper West** | | | | | | | | | |
| NPK | 46.2 | 58.3 | 33.2 | 33.2 | 0 | 0 | 0 | 124.8 | 4,291.7 |
| NPK+S | 53.8 | 69.7 | 29.5 | 29.5 | 0 | 27.1 | 0 | 155.9 | 2,857.1 |

*Number of observations: Northern=44; North East=18; Savannah=46; Upper East=55; Upper West=13; Bono=1; Bono East=15; and Ahafo=45.*

### 9.4.2 *Factors Influencing Fertilizer Use Intensity in Rice Production*

From a tobit model, the effect of specific factors on fertilizer use is presented in Table 42. The definition of variables is provided in Appendix 2. This shows that gender, farmland ownership, cultivated area, hired labor, poverty, perception of soil fertility, and regional location had a significant effect on fertilizer use intensity.

The negative effect of gender on fertilizer use intensity implies that female rice farmers used more fertilizer than the male farmers. Mensah et al. (2018) noted that, although both men and women are subject to different constraints in fertilizer adoption, men are more likely to adopt fertilizer. However, with increasing information on fertilizer and the subsidy on fertilizer, this study shows that gender gaps in the use of agricultural inputs, such as fertilizer, can be minimized, if not eliminated. Farmers who cultivated their own farmlands used significantly more fertilizer than those who cultivated lands under different land tenure arrangements. Similar to the result in Table 38, these farmers may have better understanding of the fertility of their farmlands and thus apply more fertilizer. Therefore, farmers who perceived their soils to be fertile or very fertile used less fertilizer than those who perceived their farmlands to be less fertile.

The negative effect of cultivated area implies that the larger the area cultivated by a farmer, the lower the quantity of fertilizer applied. This is because, under a capital constraint, farmers would apply little fertilizers to larger farm plots without consideration of the application rate. With the limit of access to subsidized fertilizer (15 bags maximum; MoFA, 2019), it is possible that the large-scale farmers have no extra resources to make such purchases.

The use of more hired labor leads to higher fertilizer use intensity in rice production. This is because fertilizer application is currently done manually. Therefore, more laborers are needed to apply larger quantities of fertilizer. As such, farmers who are aware of low access to hired labor or are unable to pay for hired labor may use little or no fertilizer. The effect of PPI is negative, implying that the poorer or the higher the vulnerability to poverty, the lower the quantity of fertilizer applied in rice production. This is justifiable, since poor farmers may spend their minimal resources on direct consumption and not on farm investment.

Regionally, farmers in Upper East and Bono East regions used more fertilizer than those in Northern Region, while those in Savannah and Ahafo regions used more fertilizer than farmers in Northern Region. This is consistent with the fertilizer use distribution in Table 39.

*Table 42. Factors influencing fertilizer use intensity in rice production*

| Variable | Coeff. | Std. Err. | P-Value |
|---|---|---|---|
| Gender | -64.62** | 29.96 | 0.032 |
| Youth | -2.30 | 28.12 | 0.935 |
| Extension | 7.89 | 21.70 | 0.716 |
| Credit access | 2.33 | 24.82 | 0.925 |
| FBO | 5.95 | 23.78 | 0.803 |
| Education | 1.92 | 2.43 | 0.430 |
| Experience | -0.36 | 1.14 | 0.754 |
| Leadership position | -18.12 | 22.60 | 0.424 |
| Distance from home to input shop | 0.02 | 0.14 | 0.873 |
| Ownership of mobile phone | -6.75 | 87.14 | 0.938 |
| Farmland ownership | 56.09** | 24.88 | 0.025 |
| Improved seed | 30.85 | 29.30 | 0.294 |
| Cultivated area | -17.33** | 7.66 | 0.025 |
| Hired labor | 3.79*** | 1.36 | 0.006 |
| Family labor | -1.60 | 1.42 | 0.261 |
| Non-crop income | 0.01 | 0.01 | 0.352 |
| PPI | -1.06* | 0.63 | 0.094 |
| Food consumption expenditure | 0.01 | 0.02 | 0.547 |
| **Perception of soil fertility (reference is less fertile):** | | | |
| Very fertile | -99.75** | 50.68 | 0.050 |
| Fertile | -57.28** | 23.07 | 0.014 |
| **Region (reference is Northern Region):** | | | |
| North East | -30.00 | 41.95 | 0.475 |
| Savannah | -73.19** | 35.20 | 0.039 |
| Upper East | 115.24*** | 35.83 | 0.002 |
| Upper West | 40.13 | 47.58 | 0.400 |
| Bono | 208.39 | 141.43 | 0.142 |
| Bono East | 132.58** | 51.40 | 0.011 |
| Ahafo | -181.80*** | 46.02 | 0.000 |
| Constant | 293.29 | 122.69 | 0.018 |
| Lambda | 132.94 | 7.23 | |

*Note: ***, **, and * indicate significance at 1%, 5% and 10%, respectively.*

## 9.5 Effect of Fertilizer Use on Soybean Production

### 9.5.1 *Fertilizer Use and Soybean Yield*

Table 43 shows the various quantities of active nutrients and the average quantity of various nutrient formulations used in soybean production (see quantities of fertilizer used by the soybean farmers in Table 14). The associated yield for each nutrient formulation is also presented regionally. Overall, farmers who used fertilizer had higher yields than those who did not use fertilizer. In some regions, the users of some fertilizers had lower yields than the non-fertilizer users. Farmers in North East who used NPK+Zn+MgO had almost the same yield as those who did not use any fertilizer. Regionally, the use of fertilizer in Northern Region had a higher impact on yield than in other regions. Although there is a high use of fertilizers in the Upper East Region, these have had a relatively low impact on yield. This could be explained by other covariate factors, such as rainfall, soil conditions, and farmers' attitude toward soybean production in the region.

*Table 43. Mean distribution of fertilizer use and soybean yield by region*

| Nutrient Formulation | Average Nutrient Rate (kg/ha) | | | | | | Nutrient (kg/ha) | Yield (kg/ha) | Sample |
|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | Zn | S | Mg | | | |
| **Bono East** | | | | | | | | | |
| N | 28.8 | 0 | 0 | 0 | 0 | 0 | 28.8 | 1,062.5 | 1 |
| NPK+Zn+S+MgO | 27.5 | 10 | 10 | 0.7 | 10 | 1.4 | 59.6 | 1,000.0 | 1 |
| **North East** | | | | | | | | | |
| Non-users | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,060.8 | 12 |
| N | 100 | 0 | 0 | 0 | 0 | 0 | 100 | 1,250.0 | 1 |
| NPK | 38 | 30.4 | 30.4 | 0 | 0 | 0 | 98.8 | 1,442.0 | 7 |
| NPK+S | 57.4 | 22.6 | 22.6 | 0 | 25.6 | 0 | 128.1 | 1,277.8 | 9 |
| NPK+S+MgO | 62.5 | 31.3 | 31.3 | 0 | 10 | 0.6 | 135.6 | 1,437.5 | 2 |
| NPK+Zn | 23.7 | 27.7 | 27.7 | 1 | 0 | 0 | 80 | 1,463.1 | 22 |
| NPK+Zn+MgO | 78.8 | 50 | 25 | 3 | 0 | 3 | 159.8 | 1,000.0 | 2 |
| NPK+Zn+S | 47.1 | 36 | 36 | 1.2 | 20.8 | 0 | 141.2 | 1,622.6 | 13 |
| NPK+Zn+S+MgO | 56.6 | 29.7 | 26.1 | 1.8 | 20.5 | 1.8 | 136.4 | 1,239.6 | 6 |
| NS | 36.3 | 0 | 0 | 0 | 25 | 0 | 61.3 | 1,000.0 | 2 |
| **Northern** | | | | | | | | | |
| Non-users | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,774.3 | 12 |
| N | 51.6 | 0 | 0 | 0 | 0 | 0 | 51.6 | 2,289.7 | 3 |
| NPK | 39 | 23.8 | 23.8 | 0 | 0 | 0 | 86.6 | 1,901.0 | 12 |
| NPK+S | 36.7 | 17.2 | 17.2 | 0 | 22.3 | 0 | 93.3 | 3,000.0 | 4 |
| NPK+S+MgO | 38.7 | 17.5 | 17.5 | 0 | 16.3 | 0.5 | 90.4 | 2,263.4 | 4 |
| NPK+Zn | 37.8 | 44.6 | 44.6 | 1.5 | 0 | 0 | 128.5 | 2,335.2 | 11 |
| NPK+Zn+MgO | 46.1 | 22.6 | 15.9 | 2.5 | 0 | 3 | 90 | 2,103.6 | 37 |
| NPK+Zn+S | 55.2 | 22.9 | 22.9 | 0.8 | 35.2 | 0 | 137.1 | 2,212.5 | 5 |
| NPK+Zn+S+MgO | 76.2 | 42 | 38.2 | 2 | 24.3 | 2.1 | 184.7 | 2,128.0 | 7 |
| NS | 33.1 | 0 | 0 | 0 | 27.8 | 0 | 60.8 | 1,915.5 | 5 |
| **Savannah** | | | | | | | | | |
| Non-users | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 500.0 | 5 |
| NPK | 19.1 | 19.1 | 19.1 | 0 | 0 | 0 | 57.2 | 1,000.0 | 2 |
| NPK+S | 32.1 | 16.1 | 16.1 | 0 | 18.3 | 0 | 82.5 | 1,375.0 | 4 |
| NPK+Zn | 29.8 | 36 | 36 | 1 | 0 | 0 | 102.8 | 1,000.0 | 6 |
| NS | 19 | 0 | 0 | 0 | 21.7 | 0 | 40.6 | 1,152.8 | 3 |
| **Upper East** | | | | | | | | | |
| Non-users | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,187.5 | 4 |
| NPK | 65 | 34.5 | 34.5 | 0 | 0 | 0 | 133.9 | 1,284.1 | 11 |
| NPK+S+MgO | 50.5 | 20.7 | 20.7 | 0 | 10 | 0.6 | 102.3 | 1,000.0 | 7 |
| NPK+Zn | 60.5 | 62.1 | 62.1 | 2.1 | 0 | 0 | 186.8 | 1,302.1 | 57 |
| NPK+Zn+MgO | 77.9 | 46.9 | 39.5 | 2.3 | 0 | 2.7 | 169.2 | 1,057.7 | 13 |
| NPK+Zn+S | 91.6 | 85.8 | 85.8 | 2.7 | 38 | 0 | 304 | 1,225.0 | 5 |
| NPK+Zn+S+MgO | 77 | 57.3 | 48.4 | 2.4 | 27.1 | 1.8 | 214 | 1,291.7 | 3 |
| NS | 26.3 | 0 | 0 | 0 | 30 | 0 | 56.3 | 1,000.0 | 1 |

| Nutrient Formulation | Average Nutrient Rate (kg/ha) | | | | | | Nutrient (kg/ha) | Yield (kg/ha) | Sample |
|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | Zn | S | Mg | | | |
| **Upper West** | | | | | | | | | |
| NPK | 61.6 | 56.8 | 56.8 | 0 | 0 | 0 | 175.1 | 1,375.0 | 6 |
| NPK+S | 75 | 36.3 | 36.3 | 0 | 24.5 | 0 | 172.2 | 1,465.9 | 11 |
| NPK+S+MgO | 83.8 | 34.4 | 34.4 | 0 | 22 | 0.6 | 175.1 | 1,687.5 | 3 |

### 9.5.2 *Factors Influencing Fertilizer Use Intensity in Soybean Production*

Table 44 shows the effect of specific factors on the fertilizer use intensity of soybean farmers. Among these factors, only extension, access to credit, use of improved seeds, use of hired labor, PPI, perception of soil as very fertile, and location in Savannah, Upper East, and Upper West regions significantly explained the variations in the fertilizer use intensity of the farmers.

Extension services remain crucial in the promotion of agricultural inputs and adoption by farmers. Extension officers often provide education to farmers on the importance of fertilizer and link them to fertilizer and other agro-input shops. Therefore, it is reasonable that the farmers who received extension services would use more fertilizer. Credit is a major limiting factor to the use of fertilizer (Table 15). Smallholder farmers often have less capital for investing into their farms. Therefore, with credit support, capital investment, including the use of fertilizer, would increase. The positive effect of access to credit on fertilizer use intensity is consistent with the negative effect of PPI. Thus, farmers who are more vulnerable to poverty use less or no fertilizer because of their inability to spend their limited wealth in buying fertilizer.

The type of seed used by the farmer is important in explaining fertilizer use intensity. To achieve better results with improved seeds, farmers are often encouraged to use fertilizers at recommended rates. Nationally, the PFJ program comes with a 50% price cut for both improved seeds and fertilizer. Therefore, the positive effect of improved seeds in Table 44 suggests that farmers who planted improved soybean seeds used more fertilizer. The effect of hired labor is positive and significant. Thus, the use of more hired labor leads to intensified fertilizer application on soybean farms. Irrespective of the application method, the application of fertilizer requires labor, and this places an additional labor burden on the farmers. As for maize and rice, soybean farmers who perceived their soils to be very fertile used less or no fertilizer. Farmers generally do not have access to scientific information on the status of their soils. Therefore, they depend on their own perception of the soil. Therefore, once the farmer is convinced that his or her soil can support soybean production with little or no fertilizer, the farmer's fertilizer use of fertilizer becomes less considerable.

The negative effect of Savannah Region means that farmers in this region used less fertilizer than farmers in the Northern Region. This is consistent with the results in Table 41. Conversely, farmers in Upper East and Upper West regions used more fertilizer than those in Northern Region.

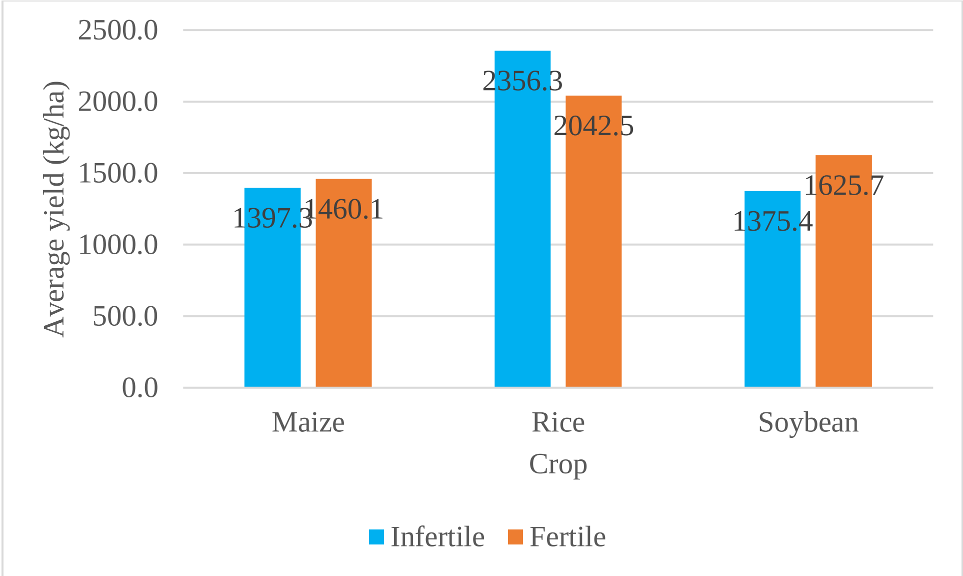
*Table 44. Factors influencing fertilizer use intensity in soybean production*

| Variable | Coeff. | Std. Err. | P-Value |
|---|---|---|---|
| Gender | -21.19 | 13.27 | 0.111 |
| Youth | -3.40 | 12.60 | 0.787 |
| Extension | 21.60** | 10.51 | 0.041 |
| Credit access | 21.46* | 12.19 | 0.080 |
| FBO | 0.73 | 11.28 | 0.948 |
| Education | -0.36 | 1.11 | 0.744 |
| Improved seeds | 36.21** | 13.87 | 0.010 |
| Farm size | -0.58 | 4.36 | 0.894 |
| Non-farm income | 0.0003 | 0.0020 | 0.861 |
| PPI | -0.75** | 0.32 | 0.018 |
| Per capita food expenditure | -0.01 | 0.01 | 0.473 |
| Mobile ownership | -29.89 | 22.36 | 0.182 |
| Land ownership | 0.99 | 12.06 | 0.935 |
| Experience | 0.18 | 0.53 | 0.729 |
| Distance from home to input shop | -0.08 | 0.05 | 0.116 |
| Hired labor | 1.13** | 0.44 | 0.011 |
| Family labor | -0.89 | 0.81 | 0.271 |
| **Perception of soil fertility:** | | | |
| Very fertile | -66.94** | 26.80 | 0.013 |
| Fertile | -8.90 | 9.81 | 0.365 |
| **Region:** | | | |
| North East | 1.72 | 13.72 | 0.900 |
| Savannah | -35.78* | 21.46 | 0.097 |
| Upper East | 73.09*** | 14.87 | 0.000 |
| Upper West | 67.33*** | 20.44 | 0.001 |
| Bono East | -75.89 | 60.06 | 0.207 |
| Constant | 195.20 | 47.33 | 0.000 |
| Lambda | 75.22*** | 3.22 | |

*Note: ***, **, and * indicate significance at 1%, 5%, and 10%, respectively.*

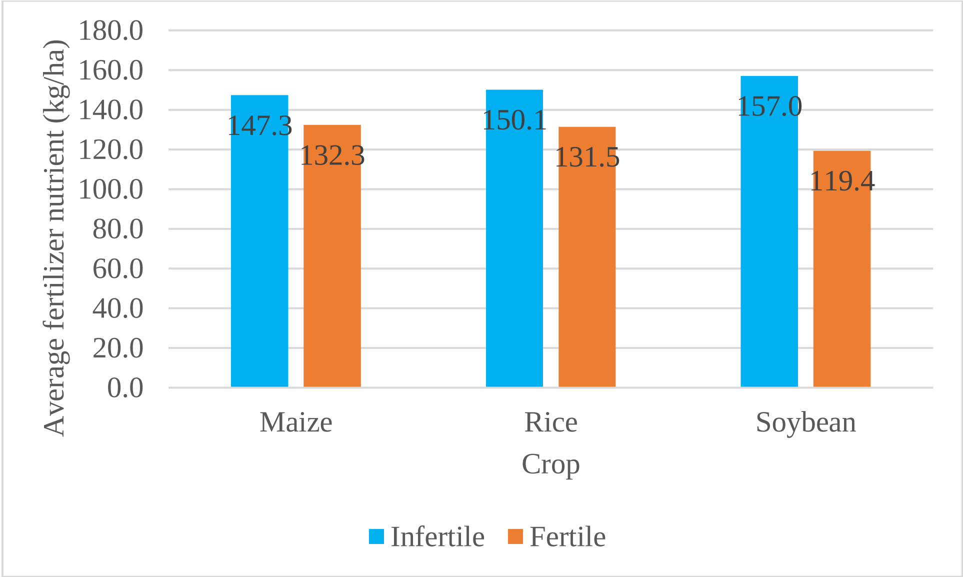
## 9.6 Crop Yield and Farmers' Perception of the Soil Fertility Status of Their Farmland

Figure 22 shows the average yield of the farmers based on their perception of the fertility status of their farmland. Maize and soybean farmers who perceived their soils to be very fertile or fertile (could support crop production with little or no use of external fertilization) had higher yields than those who perceived their soils to be infertile (could not support crop production without external fertilization). However, the differences are statistically insignificant. For rice, farmers who perceived their farmland to be infertile had significantly higher yields than those who perceived their soil to be fertile. Figure 23 consistently indicates that the farmers who perceived their soil to be infertile used a significantly higher quantity of fertilizer than those who perceived their soil as fertile.




*P-values from T-test: Maize =0.918; rice= 0.042**; and soybean= 0.998.*

***Figure 22. Soil fertility perception (fertile or infertile) and yield (kg/ha)***




*P-values from T-test: Maize =0.000***; rice= 0.003***; and soybean= 0.003***.*

***Figure 23. Soil fertility perception (fertile or infertile) and average fertilizer nutrient (kg/ha) used by farmers***

## 9.7 Fertilizer Price Type, 4Rs of Nutrient Stewardship, and Yield

Table 45 shows the mean yield distribution of various crops by fertilizer price type and compliance with the 4Rs of nutrient stewardship. There was no significant difference in the yield between farmers who purchased subsidized fertilizer and those who purchased at commercial prices.

However, the distribution shows that maize producers who purchased fertilizer at commercial prices had a higher yield than those who purchased at subsidized prices. For rice and soybean, those who purchased fertilizer at subsidized prices had a higher yield than those who purchased at commercial prices. Empirically, Andani et al. (2020) estimated that, although maize farmers in Tempane District who benefited from the fertilizer subsidy had higher yields than those who did not, they both made rational decisions, since the former would have obtained a lower yield had they not benefited while the latter would have obtained a lower yield had they benefitted.

Regarding the method of fertilizer application, the results show that farmers who broadcast their fertilizer had a lower yield for all crops than those who did not. The yield difference was statistically significant for maize and soybean. This justifies the need for farmers to adopt appropriate methods, such as side placement of fertilizer application, rather than broadcasting. For all three crops, farmers who indicated applying the recommended fertilizer type and applied fertilizer at the right time had a higher yield than those who did not. However, the difference in yield was significant only for maize farmers. Although maize farmers who indicated applying fertilizer at the recommended application rate had a significantly higher yield than those who did not, the reverse was true for soybean farmers.

***Table 45. Fertilizer price type, 4Rs nutrient stewardship, and yield***

| Description | Maize | | Rice | | Soybean | |
|---|---|---|---|---|---|---|
| | Mean (kg/ha) | Std. Dev. | Mean (kg/ha) | Std. Dev. | Mean (kg/ha) | Std. Dev. |
| **Fertilizer price type** | | | | | | |
| Commercial | 1,558 | 841.7 | 2,167.7 | 1,295.3 | 1,692.5 | 677.2 |
| Subsidy | 1,476.3 | 724.5 | 2,416.9 | 1,265.2 | 1,395.5 | 776.4 |
| Total | 1,515.5 | 783.6 | 2,282.2 | 1,284.1 | 1,566.5 | 749.3 |
| *T-value* | *1.00* | | *1.13* | | *3.40**** | |
| **Application method** | | | | | | |
| No broadcasting | 1,526.1 | 785.5 | 2,363.4 | 1,339.9 | 1,591.7 | 757.7 |
| Broadcasting | 1,462.7 | 774.1 | 2,142.5 | 1,178.6 | 1,184.6 | 478.6 |
| Total | 1,515.5 | 783.6 | 2,282.2 | 1,284.1 | 1,566.5 | 749.3 |
| *T-value* | *1.73*** | | *1.32* | | *2.25*** | |
| **Recommended fertilizer type** | | | | | | |
| Right | 1,580.7 | 830.4 | 2,358.9 | 1,340.6 | 1,617.4 | 781.7 |
| Wrong | 1,371.4 | 631.5 | 2,160.0 | 1,183.2 | 1,476.7 | 756.7 |
| Total | 1,523.3 | 786.1 | 2,294.5 | 1,291.7 | 1,566.5 | 749.3 |
| *T-value* | *3.94**** | | *0.96* | | *1.51* | |
| **Time of fertilizer application** | | | | | | |
| Right | 1,608.8 | 843.3 | 2,365.6 | 1,294.4 | 1,585.0 | 759.6 |
| Wrong | 1,247.5 | 468.1 | 2,125.3 | 1,281.5 | 1,523.9 | 728.1 |
| Total | 1,523.3 | 786.1 | 2,294.5 | 1,291.7 | 1,566.5 | 749.3 |
| *T-value* | *6.56**** | | *1.14* | | *0.60* | |
| **Recommended application rate** | | | | | | |
| Right | 1,733.9 | 894.0 | 2,135.8 | 1,187.0 | 1,417.3 | 671.7 |
| Wrong | 1,301.0 | 575.9 | 2,382.8 | 1,343.3 | 1,649.6 | 779.3 |
| Total | 1,523.3 | 786.1 | 2,294.5 | 1,291.7 | 1,566.5 | 772.6 |
| *T-value* | *9.43**** | | *-1.23* | | *-2.51*** | |

*Note: ** and *** indicate significance at 5% and 1%, respectively.*

## 9.8 Effect of Fertilizer Application on Food Security

Figure 24 shows the food insecurity status, using HFIAS, of the users and non-users of the various fertilizer types. While 34.3% of farmers who used at least one fertilizer type were food secure, 33.2% of the farmers who did not use any of the fertilizers were food secure as well. Also, while 35.8% and 12% of fertilizer users were moderately and mildly food secure, respectively, 31.8% and 15% of non-users were moderately and mildly food secure, respectively. This suggests that there is no direct relationship between the use or non-use of fertilizer and food security. This is a critical observation that needs to be further analyzed and understood, as the premise of fertilizer use is to increase crop yield and, with that, farm income and food security.

The key informant results on the effect of fertilizer application on crop production and food security revealed commendations. For instance, a key informant stated that *"[Fertilizer] increases crop productivity and helps us to have food throughout the year. It also helps us to harvest good nutritious food crops to eat and be healthy."* Another informant indicated that fertilizer is important *"to produce quality food crops and to reduce malnutrition among people, especially, children," "as a result [of fertilizer use], the yields are better, so we get a reasonable quantity of food,"* and *"fertilizers have only increased food security in this community."*

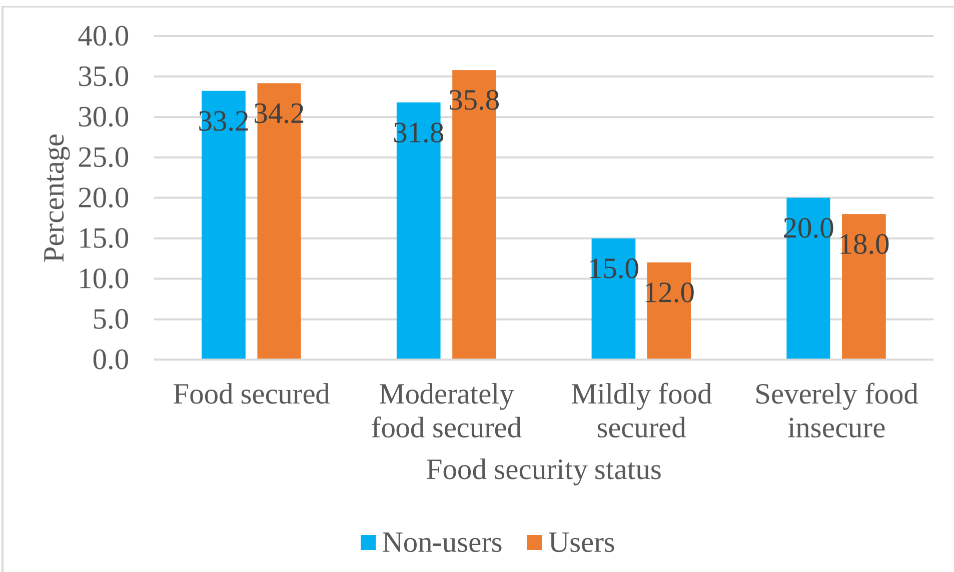



*Figure 24. Pooled distribution of food insecurity status and fertilizer use*

# CHAPTER 10: MULTIVARIATE ANALYSIS OF YIELD-DRIVING FACTORS

## 10.1 Introduction

This chapter provides a multivariate analysis of factors that influence yield. These include socioeconomic and soil factors, fertilizer application, and other production inputs.

## 10.2 Principal Component Loading of Yield-Driving Factors

Figure 25 shows the scree plot from the various components. The principal component analysis (PCA) results reveal that, out of 42 components (factors considered), 15 have eigen values above 1. However, Figure 25 reveals that there is a break in the scree plot after the fourth component (below 5% of the explained variations). Therefore, four components of the PCA are returned and their loadings shown in Table 46. Using a benchmark of 0.2, nine factors contribute highly to PC1 and 21 factors in all four components.

- Positive loadings in Table 46 indicate that the variable is positively correlated with the PC. From the first PC, cation exchange capacity, extractable potassium, extractable nitrogen, extractable phosphorus, soil organic carbon, and soil depth had a positive correlation with the other factors.
- Negative loadings indicate a negative correlation between the variable and the PC. Extractable calcium, PPI, applied phosphorus, and potassium had a negative correlation with other variables in the PC1.

Generally, the first four components explain 31.3% of the variations in the data, but this increases to about 68% with 15 components.

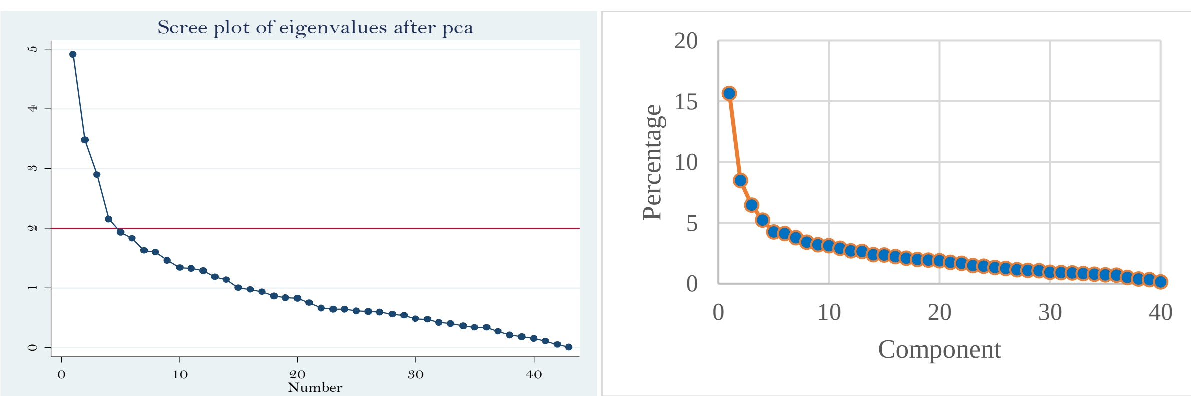



*Figure 25. Scree plot of eigen values and percentages after PCA*

*Table 46. PCA loading*

| Variable | Comp1 | Comp2 | Comp3 | Comp4 |
|---|---|---|---|---|
| Nitrogen fertilizer (kg/ha) | -0.0727 | **0.2975** | **0.2261** | -0.0420 |
| Phosphorus fertilizer (kg/ha) | **-0.2068** | **0.2003** | **0.3496** | 0.1151 |
| Potassium fertilizer (kg/ha) | **-0.207** | 0.1921 | **0.3291** | 0.1434 |
| Zinc fertilizer (kg/ha) | -0.1116 | 0.0059 | **0.3117** | **-0.2232** |
| Sulphur fertilizer (kg/ha) | -0.0073 | 0.1990 | -0.0598 | 0.0918 |
| Magnesium fertilizer (kg/ha) | 0.0204 | 0.0506 | 0.1727 | **-0.2637** |
| Farm area (ha) | 0.1061 | 0.1976 | -0.1703 | 0.0248 |
| Improved seed (kg/ha) | 0.0663 | 0.0246 | 0.0716 | 0.099 |
| Local seed(kg/ha) | -0.0004 | 0.0561 | 0.0041 | 0.0402 |
| Herbicide use (liters) | 0.1670 | 0.0557 | 0.1043 | -0.0626 |
| Labor-family (#/ha) | -0.1258 | -0.125 | 0.088 | 0.0397 |
| Labor-hired(#/ha) | -0.0318 | -0.0949 | **0.2488** | -0.0212 |
| Youth (1 if <25years) | -0.0412 | 0.1209 | 0.0162 | **0.2127** |
| Gender (1 if male) | 0.0651 | 0.0501 | -0.0194 | 0.0484 |
| Education (years) | 0.1257 | 0.1527 | 0.1294 | 0.0418 |
| FBO (1 if a member) | -0.0403 | 0.0189 | 0.0109 | -0.1071 |
| Years of farming (years) | 0.0391 | -0.1039 | -0.0411 | -0.1968 |
| Smallholder (1 if farm size <2 ha) | 0.106 | 0.1579 | -0.183 | 0.0382 |
| Extension (1 if accessed) | 0.1058 | 0.1123 | -0.0685 | 0.1298 |
| Credit access (1 if accessed) | -0.0303 | 0.0443 | 0.0082 | 0.1143 |
| Mixed cropping (1 if yes) | 0.0033 | -0.1204 | 0.1463 | -0.0825 |
| PPI (%) | **-0.2292** | -0.1620 | -0.1877 | 0.1461 |
| Very fertile soil (1 if soil is perceived as very fertile) | 0.0428 | 0.0353 | 0.0087 | 0.0323 |
| Fertile soil (1 if soil is perceived as fertile) | 0.0295 | 0.0061 | -0.168 | -0.0113 |
| Distance to input shop (km) | -0.0262 | -0.176 | -0.0601 | 0.0464 |
| Acrisols (1 if soil is acrisol) | 0.1314 | -0.1051 | -0.0122 | 0.0357 |
| Lixisols (1 if soil is lixisols) | -0.0138 | 0.1368 | -0.0547 | 0.045 |
| AWHC (v%) | 0.1224 | 0.0888 | **-0.2844** | 0.0312 |
| Soil CEC | **0.2818** | -0.1772 | 0.1706 | **0.346** |
| Soil Ca content (ppm) | **-0.2360** | **-0.2560** | 0.0589 | 0.0267 |
| Soil Mg content (ppm) | -0.1662 | **-0.2263** | 0.198 | -0.0373 |
| Soil K content (ppm) | **0.2686** | -0.1751 | -0.0424 | -0.0796 |
| Soil N content (ppm) | **0.3414** | -0.1301 | 0.1775 | **0.2575** |
| Soil pH | -0.1368 | -0.1473 | 0.0726 | **0.5110** |
| Soil OC (ppm) | **0.3566** | -0.1023 | 0.1753 | **0.2574** |
| Soil P content (ppm) | **0.2332** | -0.0605 | 0.1290 | **-0.2232** |
| Precipitation (mm) | -0.0500 | **0.3513** | -0.1520 | 0.1826 |
| Soil depth | **0.3151** | 0.0126 | 0.1186 | -0.1617 |
| Recommended fertilizer type (1 if yes) | 0.0726 | 0.1883 | 0.0972 | 0.0023 |
| Right time application (1 if yes) | 0.0611 | **0.2129** | 0.1576 | -0.0235 |
| No broadcasting (1 if yes) | -0.1403 | -0.0459 | -0.0179 | 0.1261 |
| Right application rate (1 if yes) | 0.1287 | **0.2513** | 0.1103 | -0.0052 |
| Subsidy (1 if accessed) | 0.0218 | -0.137 | 0.0378 | -0.0663 |
| **Proportion** | **11.4%** | **8.1%** | **6.7%** | **5.0%** |

## 10.3 Typology of Farmers

Figure 26 shows the biplots visualizing the distribution of the sampled farmers and the variables considered. The vector of variables indicates how an increase in these variables influences the positioning of a farmer in the space. The biplot shows that the regions sort differently on the considered variables. From the biplot, four typologies of farmers can be identified, and the characteristics are shown in Table 47.

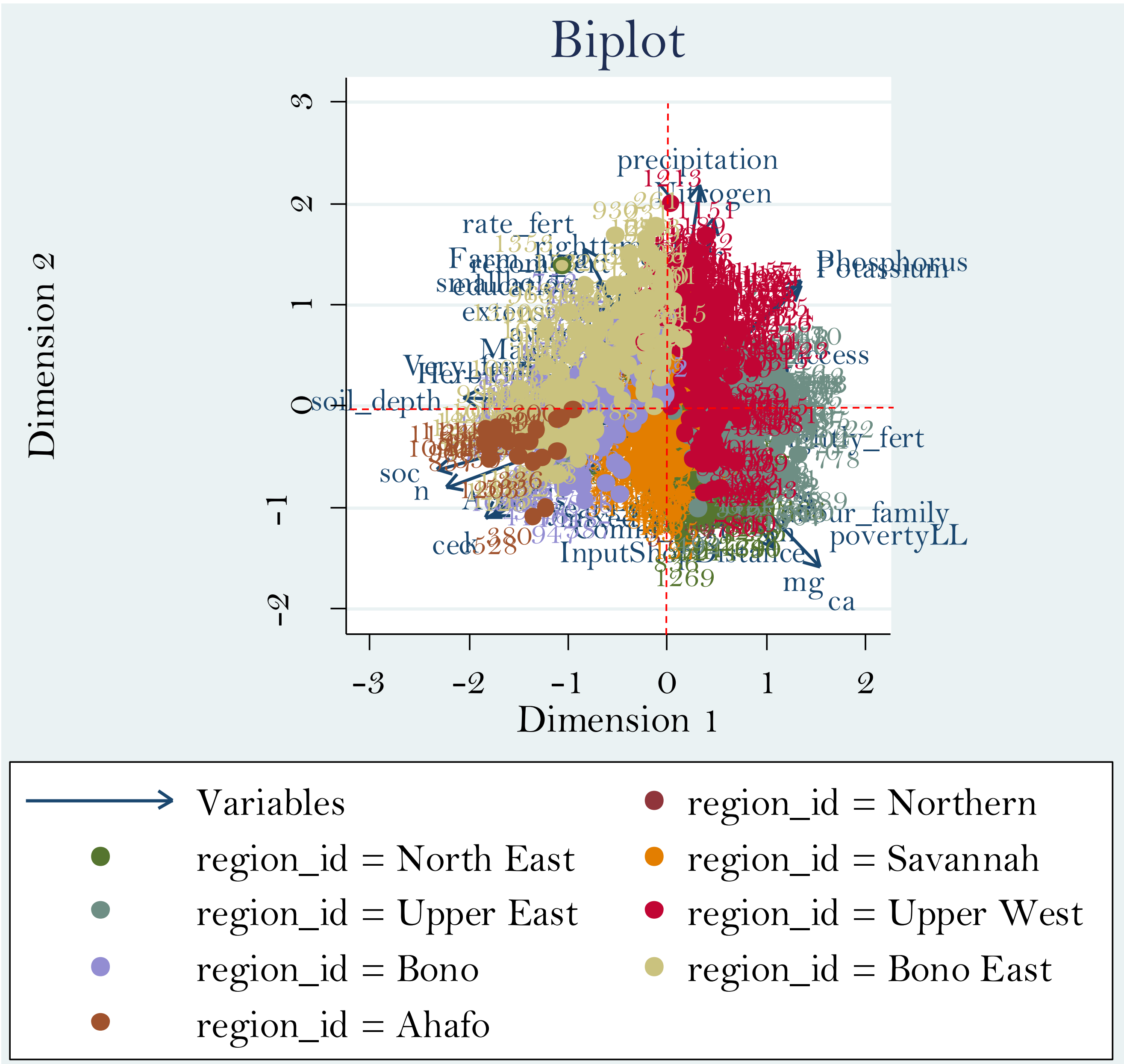



*Figure 26. Biplot of PC1 and PC2 by region sort*

Table 47 shows the factors that are related to each other and the distribution of the factor among the four groups. Table 48 details the regional distribution of farmers in each region among the four typologies.

**Typology 1:** These farmers are in a quadrant with positive correlates in both PC1 and PC2. Eleven factors are found in this typology. These include applied nutrients, local seed, lixisol soil type, and some socioeconomic characteristics. The local seed application rate for this group was lower than the recommended application rate. These farmers applied more nutrients, except for zinc, on their farms than farmers in other typologies. Similarly, most of the farmers received credit were members of a farmer group, cultivated maize on lixisol soil, and were young. The level of precipitation on these farms was also higher than in other typologies. Farmers in this group had an average yield of 1.7 mt/ha. As shown in Table 48, most farmers in North East, Upper West, Bono, and Bono East are found in this typology.

**Typology 2:** Factors for farmers in this group had negative correlates in PC1 and positive correlates in PC2. The highest proportion (14) of the factors considered in this study were found in this group. The average farm size for farmers in this groups was not different from that of other groups. The use of improved seeds was low relative to two other groups. Generally, a lower percentage of the farmers in this group had most of the characteristics. For instance, fewer farmers in this group were male, received extension service, and cultivated less than 2 ha of land. Fewer farmers in this group perceived their soils to be very fertile or fertile. Among farmers who used fertilizer, fewer applied the recommended type, at the right rate, and at the right time. Thus, adherence to three of the 4R nutrient stewardship principles was low among these farmers. The average yield for farmers in this group was close to 1.3 mt/ha. Table 48 shows that most of the farmers in this typology were from Savannah Region.

**Typology 3:** Factors for farmers in this group had positive correlates in PC1 and negative correlates in PC2. Ten factors are found in this typology. These factors include labor, soil characteristics, distance to input shops, poverty, and fertilizer application method. About 29% of farmers in this group did not broadcast their fertilizers and cultivated acrisol soils. The level of labor use by farmers in this group was not significantly different from that of other groups. On average, farmers in this group had a little over 1.3 mt/ha of maize. Table 48 shows the majority of farmers in this typology were from Northern, Upper East, and Ahafo regions.

**Typology 4:** Fewer factors are found in this group in which there is a negative correlate of the factors in both PC1 and PC2. Mostly soil characteristic factors are found in this typology. About 16% of the farmers who used fertilizer purchased it at subsidized prices. On average, farmers in this group had about 1.3 mt/ha of maize. Table 48 shows that most of the farmers in this typology were from Savannah and Upper East regions.

*Table 47. Characteristics of farmers in each quadrant*

| Variable | Typology 1 | Typology 2 | Typology 3 | Typology 4 |
|---|---|---|---|---|
| Local seed (kg/ha) | **29.7** | 35.2 | 30.4 | 27.3 |
| Nitrogen fertilizer (kg/ha) | **60.1** | 51.6 | 51.0 | 50.7 |
| Phosphorus fertilizer (kg/ha) | **26.2** | 21.6 | 22.0 | 22.0 |
| Potassium fertilizer (kg/ha) | **25.7** | 21.2 | 21.2 | 21.5 |
| Zinc fertilizer (kg/ha) | **0.5** | 0.5 | 0.6 | 0.6 |
| Sulfur fertilizer (kg/ha) | **8.3** | 6.9 | 6.2 | 5.4 |
| Precipitation (mm) | **150.1** | 148.3 | 147.7 | 146.4 |
| FBO members (%) | **36.5** | 16.5 | 30.7 | 16.2 |
| Lixisols (%) | **37.2** | 17.5 | 29.1 | 16.3 |
| Credit received (%) | **37.1** | 16.0 | 32.0 | 14.9 |
| Youths (%) | **37.7** | 12.5 | 33.3 | 16.5 |
| Education (years) | 4.9 | **3.3** | 4.7 | 3.8 |
| Farm size (ha) | 2.3 | **2.1** | 2.1 | 2.1 |
| Improved seed (kg/ha) | 40 | **28.5** | 19.4 | 39.2 |
| Herbicide (liters) | 5.2 | **4.2** | 7.3 | 5.6 |
| Magnesium (kg/ha) | 0.8 | **0.5** | 1.0 | 1.0 |
| Soil depth (cm) | 106.7 | **85.4** | 86.4 | 84.3 |
| Males (%) | 37.0 | **15.2** | 30.2 | 17.7 |
| Extension (%) | 39.0 | **13.6** | 29.7 | 17.6 |
| Smallholders (%) | 41.7 | **13.8** | 28.5 | 16.0 |
| Very fertile (%) | 50.0 | **10.7** | 24.3 | 15.0 |
| Fertile (%) | 33.1 | **16.7** | 32.4 | 17.9 |
| Right application rate (%) | 43.8 | **12.4** | 26.8 | 17.1 |
| Recommended fertilizer type (%) | 40.3 | **15.0** | 27.1 | 17.7 |
| Right time application (%) | 42.9 | **13.5** | 27.1 | 16.5 |
| PPI (index) | 50.8 | 61.5 | **57.6** | 58.2 |
| Distance to input shop (km) | 50.5 | 66.9 | **58.8** | 74.6 |
| Family labor (#/ha) | 3.4 | 3.6 | **3.7** | 3.2 |
| Hired labor (#/ha) | 5.5 | 3.8 | **4.0** | 3.9 |
| Acrisol (%) | 35.0 | 11.7 | **32.5** | 20.8 |
| Extractable calcium (ppm) | 989.4 | 1,158.7 | **1,108.6** | 1,137.8 |
| Extractable magnesium (ppm) | 216.0 | 237.1 | **230.1** | 239.1 |
| AWHC (v%) | 10.1 | 10.0 | **10.1** | 9.9 |
| Soil pH | 5.6 | 5.9 | **5.7** | 5.9 |
| No broadcasting (%) | 38.5 | 15.2 | **29.0** | 17.2 |
| Extractable potassium (ppm) | 104.0 | 109.1 | 107.8 | **107.7** |
| Total nitrogen (g/kg) | 22.4 | 18.3 | 22.5 | **19.4** |
| Soil OC (g/kg) | 22.5 | 18.3 | 21.3 | **19.0** |
| Extractable phosphorus (ppm) | 669.3 | 636.6 | 668.4 | **670.7** |
| CEC (cmol/kg) | 14.4 | 13.6 | 16.2 | **14.4** |
| Years of farming (years) | 20.4 | 22.3 | 21.0 | **21.8** |
| Mixed cropping (%) | 41.9 | 13.4 | 27.6 | **17.1** |
| Subsidy (%) | 41.6 | 16.0 | 26.1 | **16.3** |
| Yield (kg/ha) | 1,676.8 | 1,261.0 | 1,343.1 | 1,249.7 |

*Table 48. Percentage distribution of farmers by typology and region*

| Region | Quadrant | | | |
|---|---|---|---|---|
| | Typology 1 | Typology 2 | Typology 3 | Typology 4 |
| Northern | 20.2 | 18.5 | 44.5 | 16.8 |
| North East | 50.8 | 13.8 | 22.1 | 13.3 |
| Savannah | 10.8 | 27.3 | 29.5 | 32.4 |
| Upper East | 18.3 | 20.1 | 36.1 | 25.4 |
| Upper West | 72.7 | 10.8 | 8.5 | 8.0 |
| Bono | 39.5 | 15.8 | 28.8 | 15.8 |
| Bono East | 59.2 | 6.6 | 23.7 | 10.5 |
| Ahafo | 34.6 | 8.8 | 41.5 | 15.1 |

# CHAPTER 11: CONCLUSIONS AND RECOMMENDATIONS

Smallholder farmers remain central to the development of Ghana. Improving their farm productivity is no doubt a key strategy to improving their well-being and the socioeconomic development of the country. Unfortunately, smallholder farmers operate within several challenges, including deteriorating soil conditions. With the existing yield gaps and declining soil fertility, the use of fertilizer is essential to provide enough food to feed the rising population. The FERARI program recognizes that the systematic approach of promoting food systems should support widespread adoption of balanced fertilizers by farmers. This report provides evidence of the farmers and farm characteristics, fertilizer use, food security, and poverty in the Guinea Savannah and Transitional zones of Ghana.

The study established several key findings that are relevant for the program to understand its trajectory in the future. Access to institutional inputs, such as credit and extension services, were low among the farmers. With more land area allocated to maize production, there are observed differences in the cultivated land area of the farmers. For instance, although farmers cultivated an average 2.2 ha of maize, about 73% were smallholders cultivating 2 ha or less. The area cultivated by the farmers was high, considering that only about 9% of farmers in Ghana cultivate more than 2 ha (GSS, 2019a). Farmers used higher than the recommended seed rate for maize and rice production but lower than the recommended seed rate for soybean. However, most farmers still relied on local seeds for crop production. The fact that the use of more seeds increases maize yields suggests that concerns surrounding seeding rate, type, and quality must be given consideration if fertilizer use is to be promoted.

There was a low adoption of integrated agronomic practices by the farmers. This may have had an implication on their farm yields. The data also show that soybean was regarded by the farmers as a cash crop. Contrary to the subsistence description of smallholders, most farmers in this study engaged in the cultivation of maize, rice, and soybean for sales and not for direct home consumption. However, concerns over market and prices must be investigated since most of the farmers sold their farm produce at the farm gate. The majority of the farmers expressed dissatisfaction with the prices offered for their produce, divulging that the prices were low or around the breakeven point.

About 80% of the farmers used at least one form of fertilizer during the 2019 production season. The main fertilizers used by the farmers were NPK 15-15-15, urea, and AS. NKP 15-20-20+0.7Zn was also used by about one-fifth of the farmers due to its promotion under the GoG's flagship PFJ program. The key challenges to fertilizer use were limited access to credit and limited access to the subsidized fertilizers by farmers. This led to the high quantities of commercial fertilizers being used by the farmers. Farmers also mainly attributed their use of fertilizer to its ability to improve soil fertility and crop yields. Similarly, the expectations from the use of fertilizer, especially in improving yields, were met for nearly all farmers. While he use of NKP 15-20-20+0.7Zn received commendation from the farmers, this had less impact on yields than NPK+S fertilizer. The cross-cutting reasons farmers did not use each of the fertilizer types were lack of funds, unavailability, and unfamiliarity with the fertilizers. The farmers indicated their desire for fertilizer and other production-related information through ICT media, such as SMS, social media (WhatsApp), and direct phone calls. With the increasing use of mobile phones, especially smartphones, these avenues of communication can bridge the information gap between farmers and other stakeholders. The intensity of fertilizer use was influenced by a number of factors, particularly extension access, credit access, PPI, labor, perception of soil fertility, and region. These factors provide insight into how fertilizer use by farmers can be promoted in the area. Other factors, such as gender, education, experience, FBO membership, leadership, and political affiliation, had no significant effect on the intensity of fertilizer use.

The food security status of the farmers was estimated using HDDS and HFIAS. Expectedly, there was a negative correlation between the two. As HDDS increased, HFIAS decreased. The HDDS index averaged 7.6, with a range from 1 to 12. The majority of the farmers had moderate dietary diversity. Dietary diversity was high in Upper East Region and low in North East Region. Although these regions share a border, they are different in terms of culture, and this may have had an implication on dietary choices. Using the HFIAS, food insecurity was found to be high, considering that about 18% and 35% were severely food insecure or moderately food insecure, respectively. The fact that farmers rely on lower quality or less preferred foods to cope with their food insecurity condition is worrisome.

The use of fertilizer led to a positive impact on maize, rice, and soybean yields. However, the level of impact varied between the type of fertilizer formulation or level of active ingredients used, crop type, and region of the farmer. Overall, combining NPK with S led to a greater impact on maize, rice, and soybean yields than combining NPK with Zn. Nonetheless, there are regional disparities. For instance, NPK combined with Zn had a greater impact on maize yield in Upper East, Northern, and Bono East regions than NPK combined with S. Most of the farmers applied fertilizer at lower rates than recommended, and this could have dire consequences on the impact of fertilizer on the yields of the various crops. There is the need to confirm the yield difference between NPK with Zn and NPK with S fertilizers with trial-controlled data in which the application rate of both fertilizer formulations can be better studied.

The average annual income of the sampled farmers was GHS 6,597 compared to an average household food expenditure of GHS 6,915. The major source of income for many households was farm income. Therefore, improving the farm returns of the farmers would mean that their standard of living would be improved. Thus, investing in agriculture development could have a significant effect in the transformation of rural economies and the development of Ghana.

## 11.1 Indicators for Monitoring

Based on the findings of the baseline study, the following key variables should be monitored regularly to identify improvements in patterns and to ensure that the program continuously works in the direction to achieve its overall goal.

1. **Farm productivity**
    - Acreage cultivated
    - Crop yield
    - Farm income
    - Fertilizer use and farm productivity/yield
2. **Farm output handling**
    - Access to market
    - Sales and consumption volume
    - Farm profit
3. **Production factors**
    - Level of fertilizer use
    - Fertilizer application method and access to subsidized fertilizer
    - Improved seed use
    - Labor productivity
    - Adoption of integrated agricultural practices
4. **Food security and poverty**
    - Household Food Insecurity Access Scale
    - Household Dietary Diversity Score
    - Poverty level
5. **Information and marketing**
    - Access to extension services
    - Access to subsidized inputs (fertilizer and seed)
    - Access to credit

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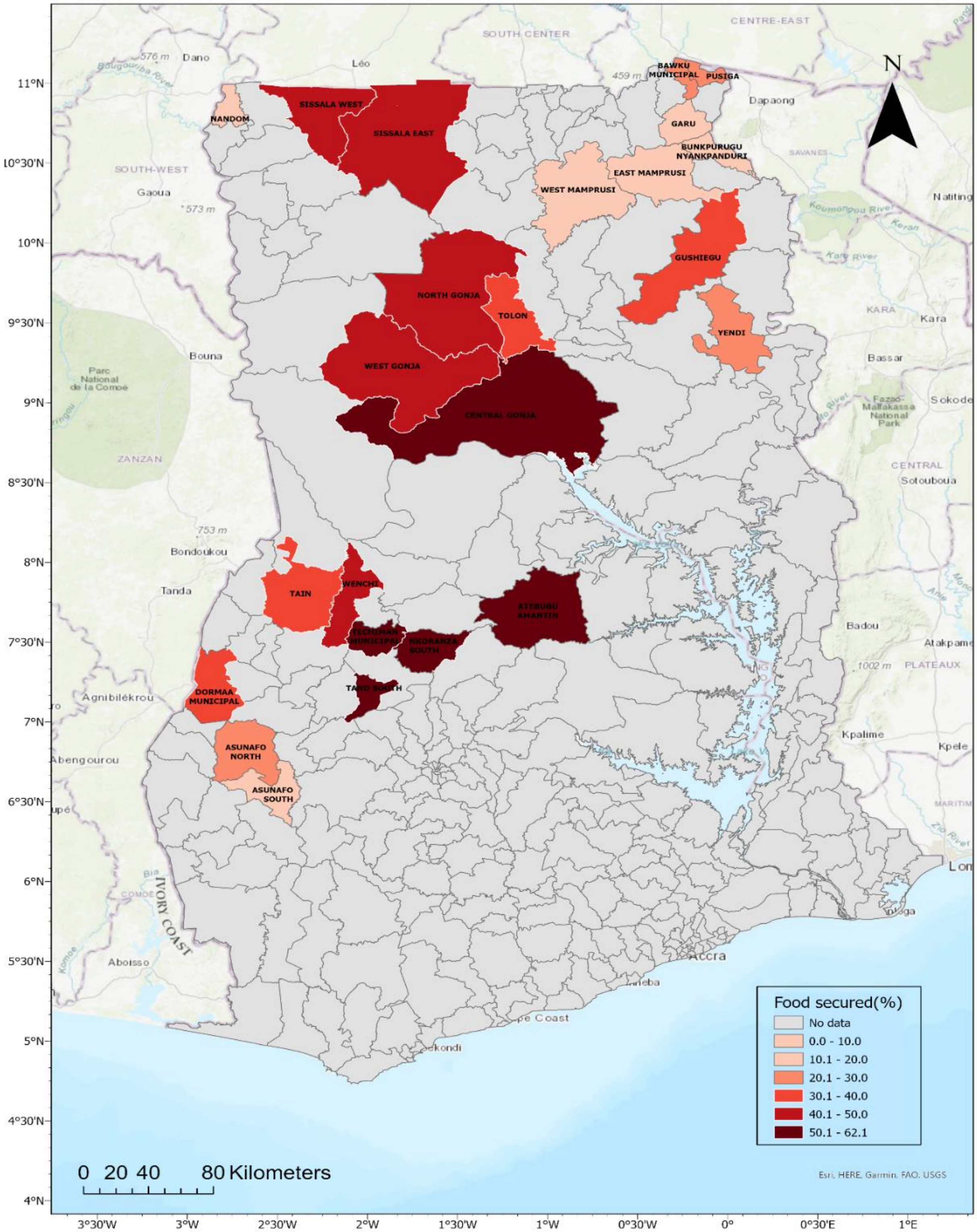
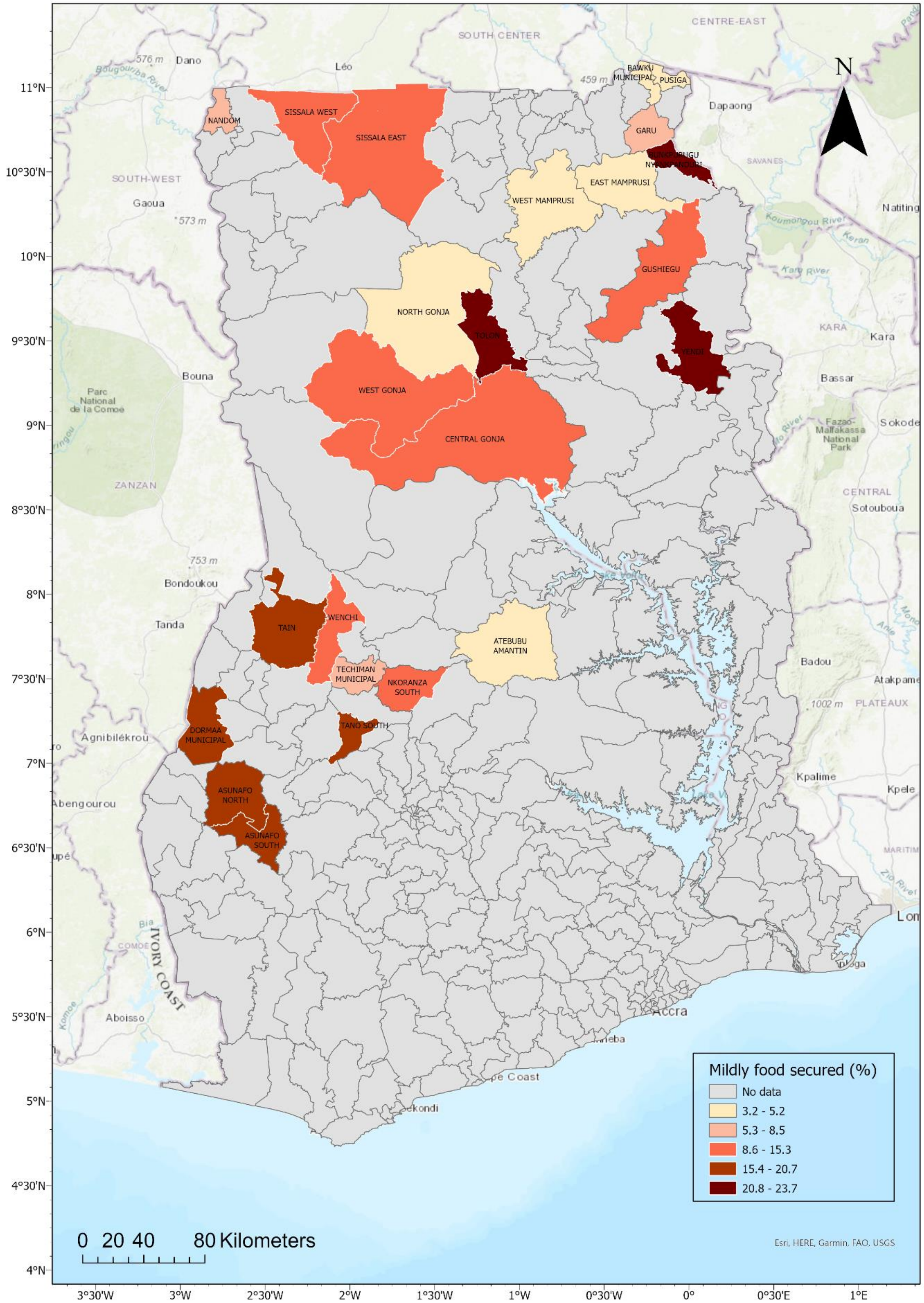
# APPENDICES

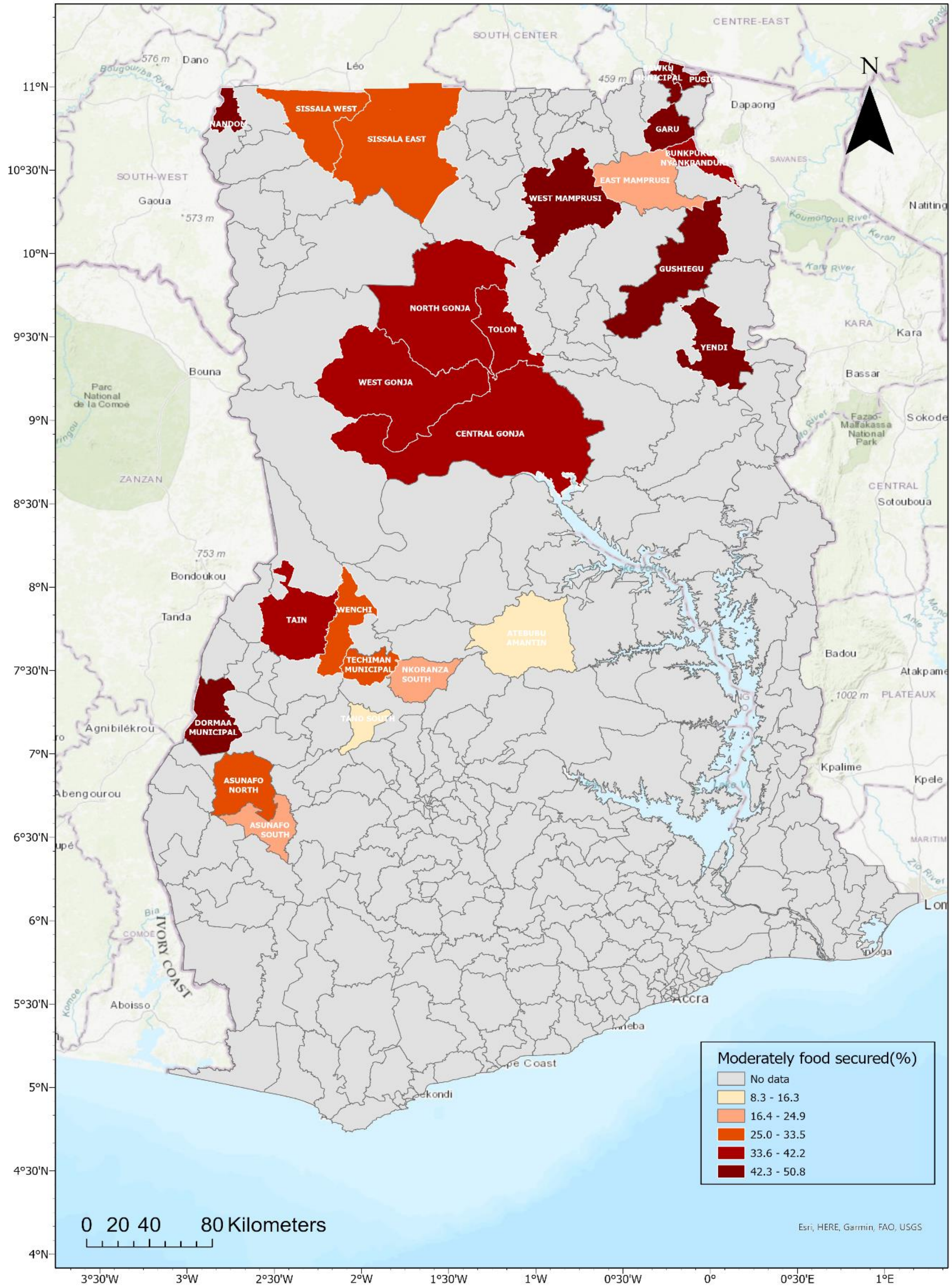
*Appendix 1a. Food secure households (%) by district*



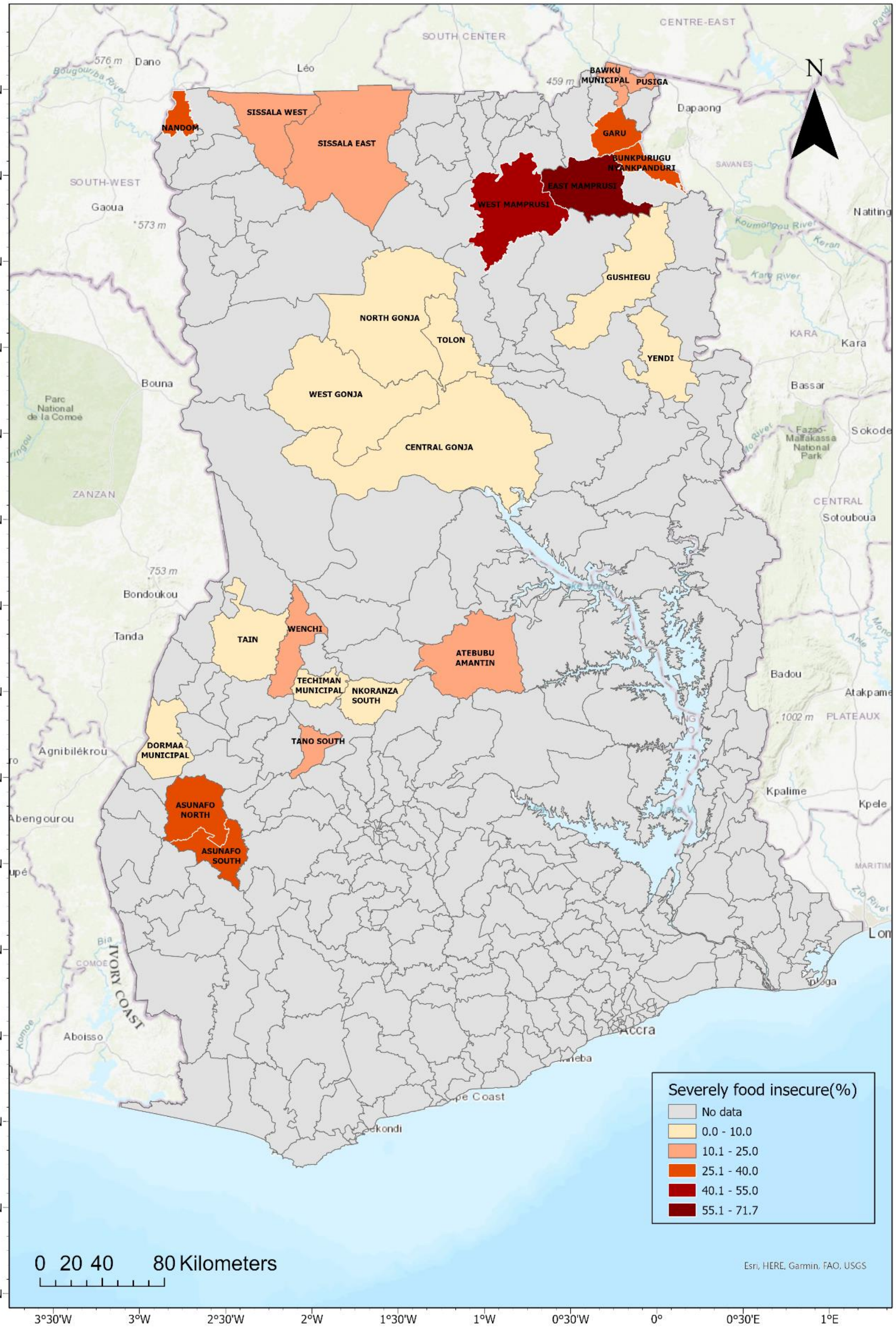
*Appendix 1b. Mildly food secure households (%) by district*



*Appendix 1c. Moderately food secure households (%) by district*



*Appendix 1d. Food insecure households (%) by district*



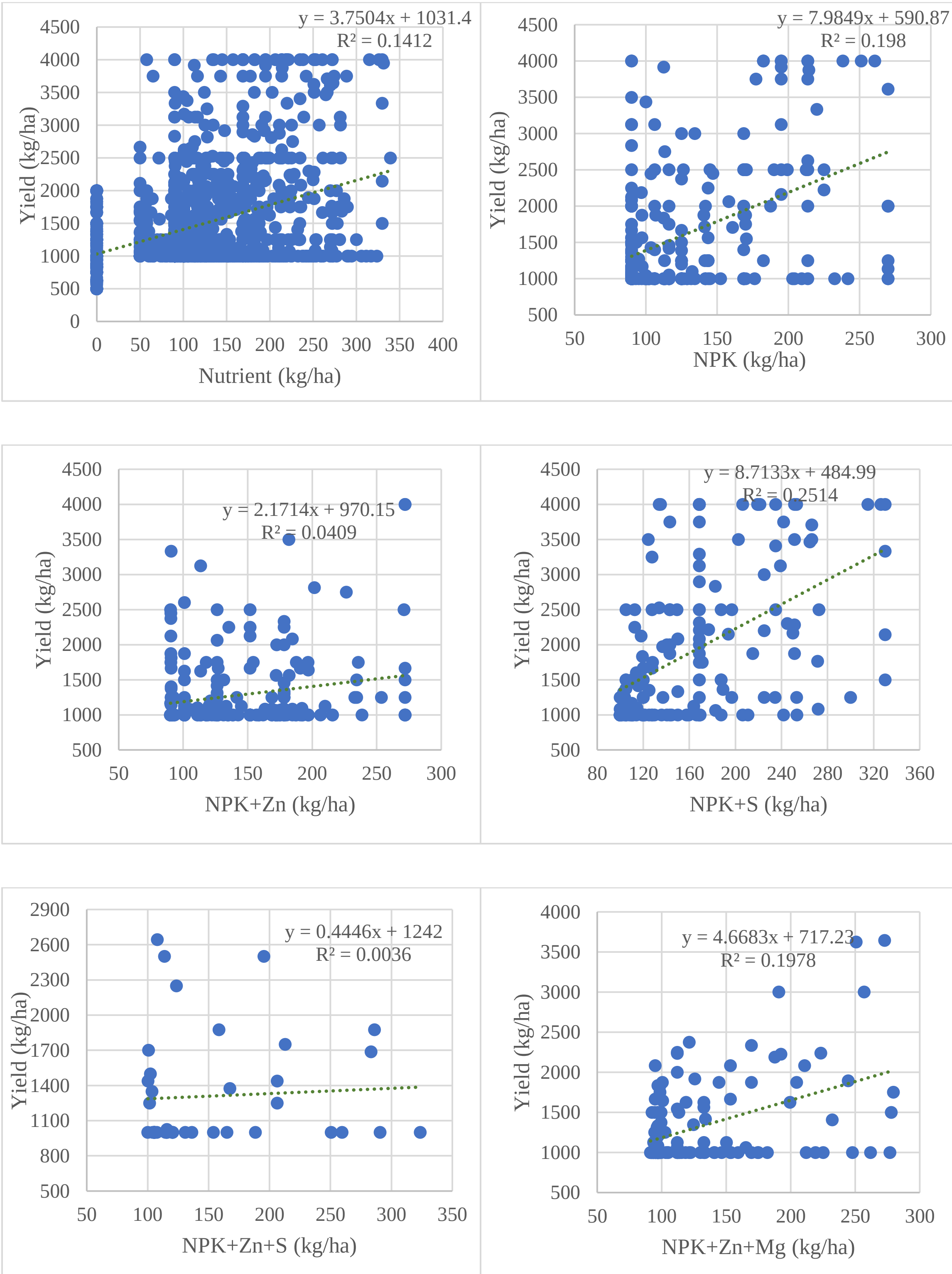
*Appendix 2. Definition of variables*

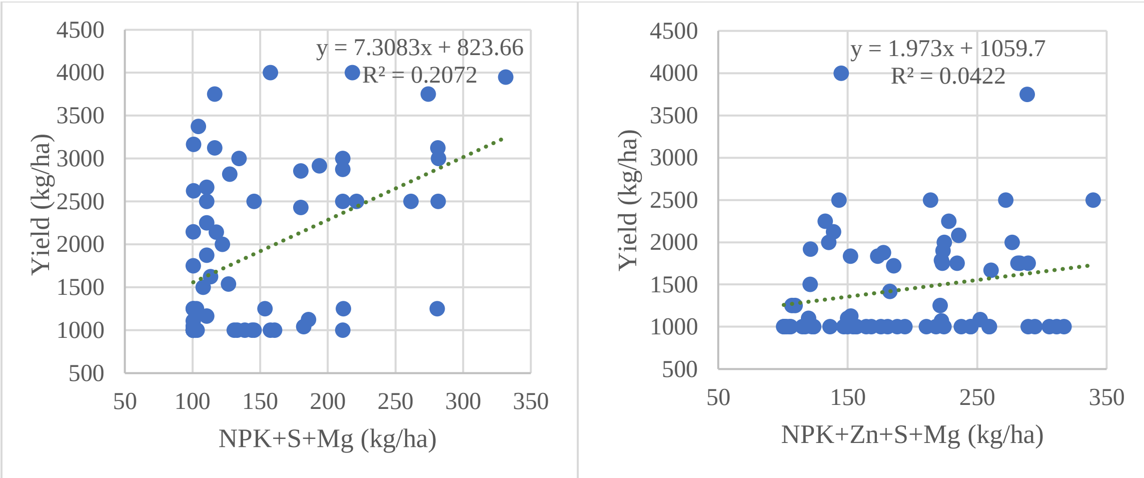
| Variable | Definition |
|---|---|
| Gender | Dummy: 1 if a farmer is a male and 0 if a female |
| Youth | Dummy: 1 if farmer is between 15-35 years and 0 if above 35 years |
| Extension | Dummy: 1 if a farmer received extension service and 0 if not |
| Credit access | Dummy: 1 if a farmer received agricultural credit and 0 if not |
| FBO | Dummy: 1 if a farmer is a member of FBO and 0 if not |
| Education | The total number of years of formal education |
| Experience | The total number of years of cultivating a particular crop |
| Leadership position | Dummy: 1 if a farmer hold a leadership position in the community or any group in the community and 0 if not |
| Distance: home to input shop | The total number of minutes a farmer have to walk to a nearby input shop |
| Ownership of mobile phone | Dummy: 1 if a farmer owns a mobile phone and 0 if not |
| Ownership of farmland | Dummy: 1 if a farmer cultivated own land and 0 if not |
| Improved seed | Dummy: 1 if a farmer cultivated improved seed and 0 if not |
| Farm size | The total land area in hectares cultivate to a crop |
| Hired labor | The total number of persons hired during crop production season |
| Family labor | The total number of family members who assisted on the farm |
| Non-crop income | The total income (GHS) received from non-farm activities |
| PPI | The poverty probability index of the farmer |
| Food consumption expenditure | The per capital annual food expenditure (GHS) of the farmer |
| Very fertile | Dummy: 1 if farmer perceived his/her farmland to be able to support maximum yield without fertilizer and 0 if not |
| Fertile | Dummy: 1 if farmer perceived his/her farmland to be able to support production but with less than expected yield without fertilizer and 0 if not |
| North East | Dummy: 1 if a farmer is located in North East Region and 0 if Northern Region |
| Savannah | Dummy: 1 if a farmer is located in Savannah Region and 0 if Northern Region |
| Upper East | Dummy: 1 if a farmer is located in Upper East Region and 0 if Northern Region |
| Upper West | Dummy: 1 if a farmer is located in Upper West Region and 0 if Northern Region |
| Bono | Dummy: 1 if a farmer is located in Bono Region and 0 if Northern Region |
| Bono East | Dummy: 1 if a farmer is located in Bono East Region and 0 if Northern Region |
| Ahafo | Dummy: 1 if a farmer is located in Ahafo Region and 0 if Northern Region |

*Appendix 3. Effects of fertilizer nutrients on maize yield*

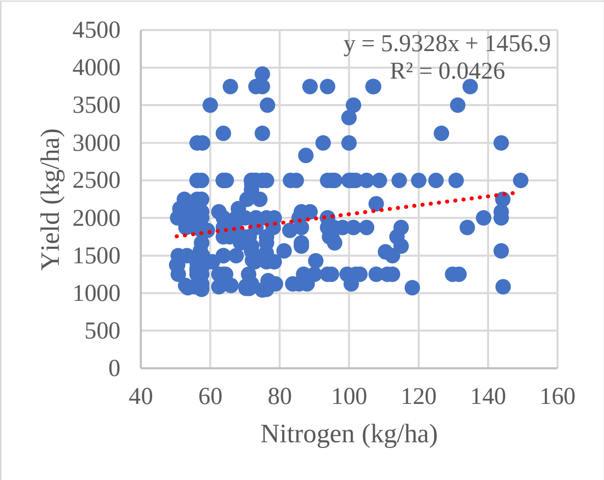
| Variable | Coeff. | Std. Err. | P>z | Coeff. | Std. Err. | P>z |
|---|---|---|---|---|---|---|
| **Output model** | | | | | | |
| Farm size | -0.017 | 0.024 | 0.478 | -0.016 | 0.027 | 0.563 |
| Improved seeds | 0.020 | 0.012 | 0.084 | 0.003 | 0.014 | 0.835 |
| Local seeds | 0.014 | 0.008 | 0.103 | 0.021 | 0.009 | 0.016 |
| Herbicides | 0.105 | 0.014 | 0.000 | 0.098 | 0.014 | 0.000 |
| Family labor | -0.004 | 0.016 | 0.808 | 0.017 | 0.017 | 0.306 |
| Hired labor | 0.038 | 0.011 | 0.001 | 0.031 | 0.011 | 0.006 |
| N | 0.059 | 0.012 | 0.000 | 0.059 | 0.012 | 0.000 |
| P | 0.265 | 0.163 | 0.103 | 0.250 | 0.161 | 0.120 |
| K | -0.209 | 0.162 | 0.199 | -0.192 | 0.161 | 0.231 |
| Zn | -0.258 | 0.038 | 0.000 | -0.234 | 0.039 | 0.000 |
| S | 0.027 | 0.009 | 0.001 | 0.028 | 0.008 | 0.001 |
| MgO | 0.029 | 0.027 | 0.272 | 0.013 | 0.027 | 0.612 |
| Constant | 6.663 | 0.135 | 0.000 | 6.705 | 0.055 | 0.000 |
| **Inefficiency model** | | | | | | |
| Youth | | | | -0.131 | 0.635 | 0.837 |
| Gender | | | | 0.426 | 0.582 | 0.464 |
| Education | | | | -0.321 | 0.165 | 0.052 |
| FBO | | | | -0.455 | 0.574 | 0.428 |
| Years of farming | | | | 0.008 | 0.020 | 0.703 |
| Smallholder | | | | -0.448 | 0.600 | 0.455 |
| Distance to input shop | | | | 0.001 | 0.002 | 0.577 |
| Extension access | | | | -0.965 | 0.543 | 0.076 |
| Credit access | | | | 0.487 | 0.553 | 0.378 |
| Mixed cropping | | | | 0.047 | 0.460 | 0.919 |
| Use of improved seeds | | | | -2.394 | 2.508 | 0.34 |
| PPI | | | | 0.028 | 0.015 | 0.058 |
| **Soil fertility** | | | | | | |
| Very fertile | | | | -28.210 | 1304.109 | 0.983 |
| Fertile | | | | -0.826 | 0.438 | 0.059 |
| Constant | | | | -4.408 | 1.793 | 0.014 |
| sigma_v | | | | 0.387 | 0.008 | |
| lnsig2v | -1.834 | 0.038 | 0.000 | -1.896 | 0.040 | 0.000 |
| lnsig2u | -11.214 | 84.987 | 0.895 | | | |
| Wald chi Sq. | 369.8 | | | 363.25 | | |

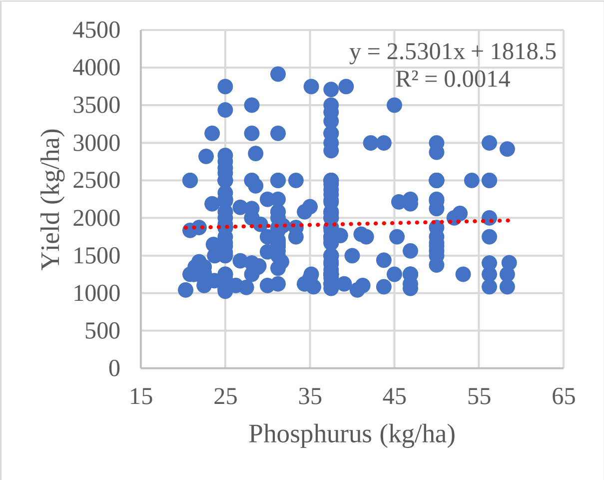
*Appendix 4.* ***Graphical representation of nutrient formulation and maize yield***

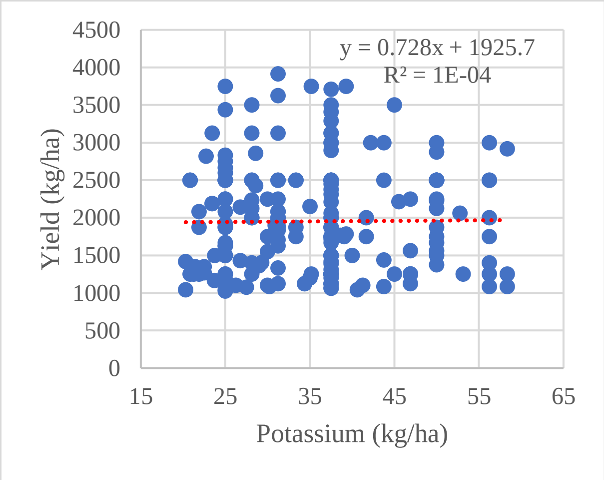


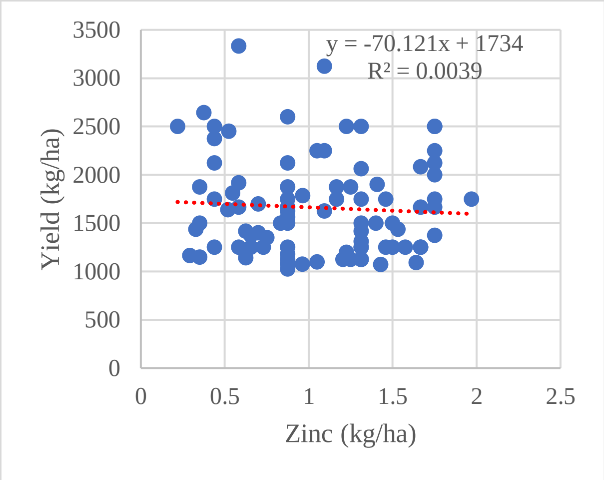

y = 7.3083x + 823.66
R² = 0.2072
Yield (kg/ha)
NPK+S+Mg (kg/ha)
y = 1.973x + 1059.7
R² = 0.0422
Yield (kg/ha)
NPK+Zn+S+Mg (kg/ha)

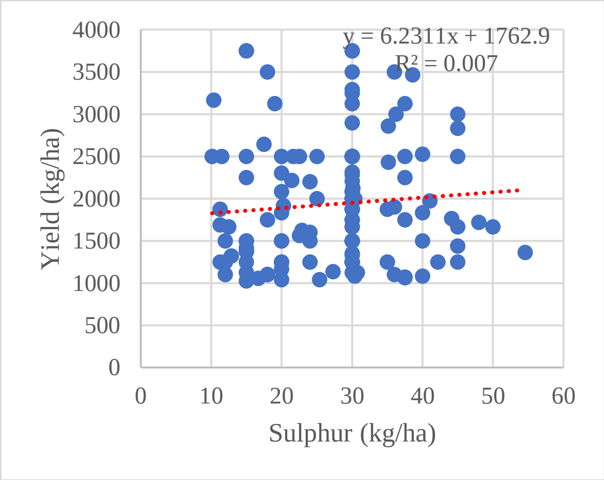
*Appendix 5. Graphical representation of nutrients and maize yield*

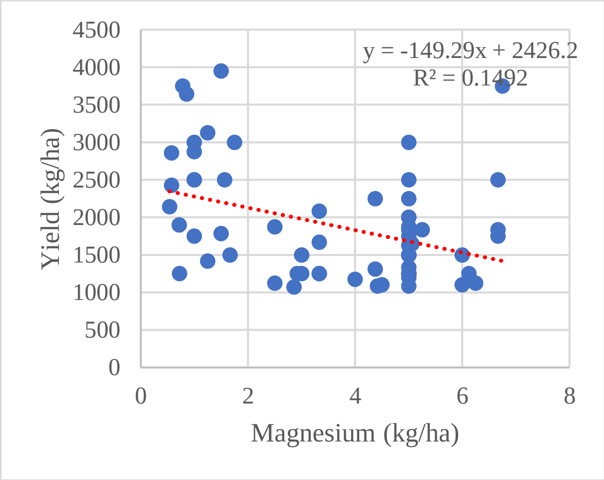


FERARI

FERTILIZER RESEARCH & RESPONSIBLE IMPLEMENTATION

FERARI is an international public-private partnership that builds science-based approaches to site-specific fertilization for widespread adoption by farmers in Ghana for improved food and nutrition security. This calls for a transformation of the fertilizer and food systems that must be driven by evidence-based agro-technical perspectives embedded in multi-stakeholder processes.

To support this transformation, the following institutions have partnered to implement the Fertilizer Research and Responsible Implementation (FERARI) program:

- International Fertilizer Development Centre (IFDC)
- Mohammed VI Polytechnic University (UM6P)
- OCP Group
- Wageningen University and Research (WUR)
- University of Liège (ULiège)
- University of Ghana (UG)
- University for Development Studies (UDS)
- Kwame Nkrumah University of Science and Technology in Kumasi (KNUST)
- University of Cape Coast (UCC)
- University of Energy and Natural Resources (UENR)
- Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED) College of Agriculture Education
- Council for Scientific and Industrial Research in Kumasi (CSIR-SRI) and in Tamale (CSIR-SARI) and its subsidiary (CSIR-SARI-Wa)

FERARI operates in conjunction with the Planting for Food and Jobs program of the Government of Ghana (GoG) to embed development efforts into national policy priorities to reach impact at scale. It trains five Ph.D. and two post-doctoral candidates and dozens of master's-level students in building the evidence base for its interventions.

FERARI conducts hundreds of fertilizer response trials on maize, rice, and soybean, on-station and also with farmers, and demonstrates them to farmer groups in the northern and middle belt of Ghana. It conducts surveys among farmers and actors in the value chain to understand the drivers for use of fertilizers and other inputs and the marketing of the produce to enhance farm productivity and income. It helps the GoG to establish a Ghana National Fertilizer Platform, developing its soil mapping expertise toward an information platform.

The content of this report is the sole responsibility of the authors of the involved institutions portrayed on the front page.

IFDC

Developing Agriculture from the Ground Up