`

ANALYSIS OF THE EFFECTS OF FERTILIZER SUBSIDIES ON CROP DIVERSIFICATION AND INCOME AND THEIR IMPLICATIONS FOR DIET QUALITY IN THE UPPER WEST REGION OF GHANA

BY

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DECLARATION

This thesis is my original work and has not been presented for an award in any other university.

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DEDICATION

This thesis is dedicated to my loving parents, Stephen and Mercy Asirifi; my nephews (*Stephen, Akwasi Okyere, Kwaku Adutwum, Reginald and Shedad*); and my nieces (*Otubea, Angela, Ntiriwaa, Christabel, Maame Dedaa, Maame Sika and Nana Abena*)

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LIST OF ABBREVIATIONS AND ACRONYMS

CDI	Crop Diversification Index
CFSVA	Comprehensive Food Security and Vulnerability Analysis (Ghana)
FAO	Food and Agriculture Organization of the United Nations
FCS	Food Consumption Score
FGD	Focus Group Discussion
GFSP	Ghana Fertilizer Subsidy Program
GHS	Ghana Health Service
GLSS	Ghana Living Standards Survey
GPRS	Ghana Poverty Reduction Strategy
GSS	Ghana Statistical Service
HCI	Household Commercialization Index
HI	Herfindahl Index
IFPRI	International Food Policy Research Institute
KII	Key Informant interview
METASIP	Medium Term Agriculture Sector Investment Plan (Ghana)
MICS	Multiple Indicator Cluster Survey (Ghana)
MoFA	Ministry of Food and Agriculture (Ghana)
NGO	Non-Government Organization
OLS	Ordinary Least Squares

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PFJ	Planting for Food and Jobs program (Ghana)
RoG	Republic of Ghana
SDGs	Sustainable Development Goals
SRID	Statistics, Research and Information Directorate *of the Ministry of Food and Agriculture* (Ghana)
SSA	Sub-Saharan Africa
THI	Transformed Herfindahl Index
USAID	United States Agency for International Development
WFP	World Food Program

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ABSTRACT

Despite the contribution of the Ghana's Fertilizer Subsidy Program (GFSP) to increased food production, diets, especially of rural households, are still poor: lacking diversity and essential nutrients. Pro-staple strategies to tackling food insecurity, as in the case of the maize-biased GFSP, have been criticized to have potentials of reducing diversification in production, a situation which could impact negatively on nutritional diversity of rural households who are mostly subsistence-oriented. This assertion is, however, not conclusive because the potential gains in income and purchasing power from the subsidy program are expected to boost diet quality via market purchases. The relative manifestation of these two seemingly opposing views is not empirically established in Ghana and many Sub-Sahara African (SSA) countries.

Using primary data from 247 randomly selected farming households in the Upper West region of Ghana, this study contributes to the discussion by exploring the pathway effects of Ghana's FSP on diet quality. Specifically, the study first compared the structure of food production and consumption between participants and non-participants of the fertilizer subsidy program (GFSP). Secondly, it examined the effects of the GFSP on crop diversification and income, and finally, assessed their subsequent relative implications for diet quality, as indicated by Food Consumption Score (FCS).

Descriptive analysis and a three-step econometric approach were used to achieve the stated objectives. The first two stages of the econometric procedure involved the application of a two-step endogenous treatment regression model to determine the effects of the GFSP and other factors on levels of crop diversification and income. The final stage used an Ordinary Least Squares (OLS) regression model to assess the individual contributions of crop diversity and income achieved from the previous stage on diet quality.

The results show that the GFSP increased farm income significantly, but had a negative effect on crop diversification. However, in terms of quality of food consumption, the income gains observed did not appear to make up for the loss in production diversity. Production diversification was a stronger contributor to diet quality than farm income. Other factors like distance to market, female involvement in household agricultural decisions and non-farm income had significant effects on diet quality.

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These findings call for an effective expansion of the subsidy program to support a wider range of crops for both subsistence and income. The study also recommends an upgrade of market and physical infrastructure, and boosting of women's productive and income control capacity to leverage the GFSP properly for quality diets. Ensuring market integration and support to general livelihood diversification are also recommended.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

Hunger and malnutrition continue to be major problems in many developing countries, especially in Asia and Sub-Sahara Africa (SSA). According to Development Initiatives (2017), 88 percent of countries in the world are faced with two or three forms of malnutrition. An estimated 2 billion people suffer from some micronutrient deficiencies, while 155 million and 52 million children are stunted and wasted respectively. According to the International Food Policy Research Institute (IFPRI, 2016), Africa and Asia alone account for almost all of the world's cases of stunting, with Africa emerging as the only continent to have recorded increased rates in recent years.

Ghana has, however, been one of the few countries in the world to have made steady improvements in reducing malnutrition over the last two decades (IFPRI, 2016). According to the Ghana Statistical Service (GSS, 2015), prevalence of child underweight and stunting reduced from 23 percent and 34 percent in 1988 to 14 percent and 19 percent respectively by 2014. These improvements in nutrition situations have been spiraled by political stability and rapid economic growth, along with sound policies which are focused on child health and parental care, including free delivery of insecticide treated bed nets; immunization; free care during pregnancy and delivery; micronutrient supplementation; and industrial fortification (IFPRI, 2016). Social protection strategies like school feeding and in-kind and cash transfers have also contributed to this achievement. However, Webb et al. (2012) assert that such nutrition-specific strategies are usually not easily accessible, acceptable nor sustainable to rural households. This is one possible reason for the rural-urban disparities of malnutrition situation in Ghana. Indeed, the Multiple Indicator Cluster Survey (MISC) of Ghana shows rural-urban differences in access to nutrition-specific interventions (GSS, 2011). For example, the Upper West region recorded the lowest

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coverage of interventions like iron supplementation (9 percent) and deworming medications (13 percent), compared to 37 percent and 48 percent respectively for the Ashanti region (GSS, 2011).

The Ghana Demographic and Health Survey (GSS, 2015) reports that rural children are over two times more likely to be severely stunted than urban children. Similarly, rural children (13 percent) are more likely to be underweight than urban ones (9 percent). Nation-wide, 64 percent of all Ghanaian children suffer from some form of anemia (a micronutrient deficiency), but it is more prevalent in rural areas (78 percent) than urban areas (58 percent). According to Aheto et al. (2015), 40 percent of all deaths of children under age five in Ghana are associated with malnutrition. Other micronutrient deficiencies including those of vitamin A and iron are critical public health challenges with the highest burden on young children and women living in rural areas (USAID, 2012).

As observed by Ghana's National Nutrition Policy (RoG, 2014), inadequate food intake and, particularly, poor dietary diversity, are the main causes of rural malnutrition; with poverty being a key underlying factor. The Comprehensive Food Security and Vulnerability Analysis (CFSVA) of Northern Ghana (Hjelm and Dasori, 2012) for instance confirms low dietary diversity in many districts in the area, with these situations further compounded by high levels of poverty; and poor infrastructure and its resultant high food prices. Characterized by 80 percent smallholders, Upper West, a rural and agriculture-dominated region in Northern Ghana, suffers from several forms of food insecurity and malnutrition (Nyantakyi-Frempong, 2017). About 70 percent of the region's population lives below the poverty line (GSS, 2014) with a high illiteracy rate and malnutrition almost twice the national average (Glover-Amengor et al., 2016).

With the fact that nutrition-specific interventions hardly reach rural households in mind, agricultural strategies have received a lot of advocacy and policy attention as an important entry point to solving rural food and nutrition insecurity issues in developing countries (Fan and Pandya-

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Lorch, 2012). However, in many parts of the developing world, agricultural strategies aimed at tackling rural food insecurity and poor nutrition are centered on boosting the production of staple crops to improve local food availability and incomes (Pinstrup-Anderson, 2007; Frelat et al., 2016). Although these strategies have been quite successful in reducing hunger throughout the world, they have as well contributed to a reduction in levels of on-farm diversification (Pingali, 2015). Diversification in production and general food systems are identified as strategies to boost diet quality, especially of subsistence-oriented households (Herforth, 2015; Berry et al., 2015; Pingali, 2015). Therefore, interventions that have potentials of compromising diversification in production must be looked at critically. In a typical subsistence setting, it is assumed that the wider the range of output by way of diversification, the wider the range of foods consumed. However, consistent with global trends, Arimond et al. (2012) observed that agricultural and food policy in SSA is concentrated on increasing production figures of staple foods at the expense of other foods with nutritional and income potentials.

Indeed, Ghana's main agricultural and food policy tool, the Ghana Fertilizer Subsidy Program (GFSP), just like many of its kind in SSA, has its objectives connected primarily to boosting local staple food availability (Wanzala-Mlobela, et al., 2013; Houssou et al., 2017). The program was originally introduced in 2008 as an emergency response to the food crisis in 2007/2008, but it is today the country's biggest agricultural policy tool. Years after its inception, national figures indicate increased crop production and achievement of near national food self-sufficiency since 2011 (RoG, 2017). Hunger and food insecurity situations at the national level have also improved steadily (Houssou et al., 2017). However, household diet quality, by way of diversity and nutritional richness, continues to be a major issue in parts of the country, especially the Northern regions which are priority target areas of the GFSP. This could be a vindication of the arguments of opponents of staple-biased approaches to tackling food insecurity. Hawkes (2007) and Cornia

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et al. (2012) observed that agricultural policy that promotes over-dependence on staple cereals is associated with increased reduction in the production and consumption of other important foods. These assertions are, however, inconclusive because despite the potentials of such strategies to discourage diversification, they could be associated with gains in income and purchasing power to support diet quality and diversity through market purchases (Snapp and Fisher, 2015).

1.2 Statement of the research problem

Ghana's remarkable improvements in reducing malnutrition over the past three decades have been spiraled by political and economic stability; and sound health and nutrition-specific interventions. However, the improved national nutrition situation is characterized by massive regional and rural-urban disparities (IFPRI, 2016; Frempong and Annim, 2017). An immediate cause of malnutrition globally, and in Ghana, is poor dietary intake and diversity (FAO, 2015). Rural areas in Northern Ghana are particularly reported to have poor food consumption patterns. In the Upper West region, food consumption is predominantly limited to starchy cereals and some leafy vegetables (Hjelm and Dasori, 2012). Consumption of pulses, fruits, meat/fish and milk/dairy products are limited. According to the sixth round of the Ghana Living Standards Survey (GLSS), fruits and milk products are consumed less than once a week with pulses coming along just about two days in a week (GSS, 2014). Poverty and low levels of development are key contributory factors to the generally poor household welfare in the region.

The celebrated Fertilizer Subsidy Program (GFSP), instituted in 2008, has partly contributed to the country's achievement of near food-self-sufficiency and reduction of hunger in recent years (RoG, 2017). However, rural diets are still poor: lacking diversity and important micronutrients (Glover-Amengor et al., 2016; Frempong and Annim, 2017). This then raises a question about the

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feasibility of tackling poor diet and under-nutrition through conventional pro-staple agricultural strategies through interventions such as the GFSP.

The widely employed pro-staple approaches, as in the case of the maize-biased GFSP, give rise to a debate with the two major possible pathways through which agricultural interventions affect diet quality forming the basis for two opposing views. Opponents to the pro-staple strategies argue that such programs' bias towards staples could lead to an over-dependence on the biased crop. This could result in a compromise in diversification, hence weakening the subsistence pathway from agriculture to nutritional diversity, which in many cases in SSA is very important for farm households (Jones et al., 2014; Sibhatu et al., 2015; Pingali, 2015). On the other hand, proponents argue that despite their potential negative impact on production diversification, such interventions' association with intensification and adoption of modern technologies could come with gains in income and purchasing power (Snapp and Fisher, 2015). This could support the income pathway from agriculture to nutrition, which is thought to be more powerful, given the right market and infrastructural environment (Dillon et al., 2015; Koppmair et al., 2017).

The potential manifestation of these pathways are thus mixed and contextual. For example, Ndlhovu (2011) and Snapp and Fisher (2015) showed that crop-biased subsidy programs actually encouraged diversification because intensification of the supported crop made more land available for the production of other crops. Snapp and Fisher (2015) further showed that this led to improved diets through both crop diversification and market purchases. On the contrary, Cornia et al. (2012) and Chibwana et al. (2012) found specific-crop-bias interventions to be associated with a decrease in on-farm diversification, and in the case of Cornia et al. (2012), observed subsequent negative impacts on child nutrition. These mixed results from literature suggest that there exists synergies and tradeoffs in the relationship between staple-biased interventions and diet quality.

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The position of Ghana in this debate is however not known nor documented. The relative manifestation of the two seemingly opposing views is not empirically established. Specifically, the role of such interventions in shaping the structure of food production and consumption in Ghana is not precisely documented. Also, the contribution of Ghana's FSP and other factors in influencing crop diversification outcomes and farm incomes are not certain. Most importantly, the implications of crop diversification and income gains/losses from the subsidy program for rural diets, are not known. Thus, the possible pathways through which the country's flagship agricultural intervention program improves not just food sufficiency and availability, but also quality of consumption, are not well explored, hence the motivation for this study.

1.3 Objectives of the study

The main objective of this study was to analyze the effects of Ghana's Fertilizer Subsidy Program (GFSP) on crop diversification and income, and their subsequent implications for diet quality in the Upper West region of Ghana.

The specific objectives were to:

1. Compare the structure of food production and consumption between participant and non-participant households of the GFSP.
2. Assess the effects of the GFSP on crop diversification and incomes.
3. Examine the implications of crop diversification and income gains from the GFSP for household diet quality.

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1.4 Research hypotheses

1. Production and consumption outcomes of GFSP participant households are not different from those of non-participants.
2. The GFSP does not affect crop diversification and incomes
3. Crop diversification and income gains from the GFSP have no influence on quality of household diets.

1.5 Justification of the study

The study broadly aligns itself with the global agenda of promoting nutrition-sensitive agricultural approaches which target poor rural households in developing countries. Recognizing the direct link between agriculture, food security and nutrition, Ghana's national nutrition policy acknowledges the important role that agriculture has to play in a multi-sectorial approach to achieving its broad goal of ensuring optimal food intake, nutrition and health of all people living in Ghana (RoG, 2013a). Similarly, the country's food and agricultural sector has a broad agenda which is linked to the national vision of eradicating rural poverty and achieving food and nutrition security, as outlined in the Ghana Poverty Reduction Strategy (GPRS) paper. This study contributes to these visions and efforts to leveraging agriculture for acceptable diets and by extension nutrition.

Characterization of the structure of production and food consumption helps to identify production and consumption outcomes that are responsive to input subsidies. Similarly, assessment of the influence of the GFSP and other factors on crop diversification and income provides insights on options for building the capacity of rural households to ensure diversity in local food availability through own production and gains in income and purchasing power.

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Furthermore, understanding the relative implications of crop diversification and income gains from the GFSP for diet quality provides evidence on the pathway effects of the program, and helps identify the most responsive pathway. Importantly, assessment of other factors influencing each of these pathways provides options on practical entry points to leveraging agriculture properly for acceptable diets.

Contributions of these findings to local policy-making enhances Ghana's efforts towards achieving its international commitments to food security and nutrition. These include the Malabo declaration to improve nutrition, and to bring child underweight and stunting to 10 percent and 5 percent respectively by 2025; and the Sustainable Development Goal (SDG) number 2 of ending hunger, achieving food security and improving nutrition.

Rural households also stand to benefit from the findings of this study, as it provides information on alternative and sustainable strategies to addressing their nutritional needs. Current nutrition-specific and health interventions like supplementation and fortification have been found to be not easily accessible, acceptable nor sustainable to rural communities (Webb et al., 2012).

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CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of the Ghana Fertilizer Subsidy Program

In an effort to improve agricultural productivity and modernize agriculture, Ghana's government has been running a nation-wide fertilizer subsidy program which has seen expansion and received political commitment since its inception in 2008 (Fearon et al., 2015). The program's stated objectives include boosting fertilizer use and improving the production of local grain staples, and ultimately improving food availability, farm incomes and food security (Wanzala-Mlobela et al., 2013; Houssou et al., 2017).

Ghana's fertilizer subsidy program started with a voucher system which targeted only smallholder farmers. In this system, the subsidy was received by farmers in the form of region-specific vouchers through agricultural extension officers in their various operational areas (Benin et al., 2013). The vouchers were used by farmers to purchase fertilizer from accredited input dealers in their region at the subsidized prices. The input dealers subsequently transmitted the redeemed vouchers to an importer who then passed on an invoice worth the value of the voucher to the Ministry of Food and Agriculture (MoFA) to receive payment (Houssou et al., 2017). But as from the 2010 season, the waybill system which is universal in nature was adopted. Here, port handling charges and related costs including those of loading and transportation, and agents' commissions and margins were absorbed by the government to arrive at a price deemed affordable for farmers (Benin et al., 2013). In this case, accredited fertilizer companies imported fertilizer and transported them to their designated regions to be sold to famers through their registered input sales agents/dealers at the subsidized price (Benin et al., 2013). The adoption of the waybill system was necessitated by some weaknesses in the voucher system, including the diversion of subsidized

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fertilizer from the target beneficiaries, and high administrative and overhead costs (Baltzer and Hansen, 2011).

In the year 2017, the government of Ghana introduced the Planting for Foods and Jobs (PFJ) program, a complementary agricultural intervention program to the GFSP. The GFSP which had been running since 2008, although not replaced with the PFJ, was homogenized with the latter and ran concurrently in the 2017 season (RoG, 2018). This led to a few changes in the operations of the original GFSP. Compared to previous years, more subsidized inputs were delivered and the subsidy rate increased from a previous 26 percent to 50 percent (Houssou et al., 2017; RoG, 2018). According to the agricultural sector progress report of 2017 (RoG, 2018), the quantity of subsidized fertilizer provided in 2017 was 121 percent more than that of 2016. Additionally, a more flexible payment plan was introduced. For example, farmers were allowed to pay half of the subsidized price and pick inputs, and pay the remainder after harvest and sale of output. Also, although the program continued to be universal, resource-poor farmers were given more preference, such that farmers with land sizes ranging from 1 to 5 acres were prioritized.

Over the years, the GFSP has been quite successful in achieving some of its stated objectives including increasing fertilizer use and increasing food production: contributing to an achievement of national staple food self-sufficiency and a reduction in food insecurity since 2011 (Mustapha et al., 2016; RoG, 2018).

Although the review above throws light on the priority the program receives in national agricultural policy efforts, and shows evidence of its contribution to food production and reduction in hunger, its contribution to quality of diets is not precisely known or documented. This study contributes to the literature by placing a special focus on the pathway effects of GFSP on quality of food consumption.

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2.2 Food production and consumption patterns in Northern Ghana

The agriculture sector provides employment to almost 50 percent of the labour force in Ghana, and is dominated by smallholder farmers. About 82 percent of all agriculture in Ghana is smallholder operated (Wiggins and Keats, 2013). Major food crops cultivated in Ghana include maize, cassava, yam, plantain, rice, sorghum, millet and cowpeas. Livestock production is also active and has experienced increasing growth since 1996, with the northern regions being the leading producers (RoG, 2013b). Recently, interventions to promote fish-farming and non-conventional livestock (like rabbits and grass cutters) production have also been rolled out and witnessed a good reception, with domestic aquaculture production showing an annual increase of 15 percent (RoG, 2017).

At the national level, Ghana experiences sufficient domestic supply of major staples. The country's 2016 food balance sheet showed sufficiency and increased growth (2 percent) in all major staples except rice and millet (RoG, 2017). The increase was majorly due to rising yields.

Food production in Ghana is mainly for sale (RoG, 2013b), but most rural households, particularly in Northern Ghana, rely on own production for much of their food needs (GSS, 2013). According to the living standards survey of 2014, rural households were five times more reliant on own production for food than their urban counterparts (GSS, 2014). By area, the Upper West recorded the highest value of consumption from own production, with roots/tubers and grains (70 percent) dominating foods consumed. Hjelm and Dasori (2012) report that, of the three northern regions, Upper West is the least dependent on cash purchases (51 percent) for food. This is not surprising considering that incomes are very low in the region and poverty is widespread (GSS, 2014).

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Smallholders, defined as farmers cultivating less than 5 acres of land, make up 62 percent of the population of the three northern regions combined, and over 21 percent of these farming households have extremely poor diets according to the Comprehensive Food Security and Vulnerability Analysis (Hjelm and Dasori, 2012). Extremely poor diets is defined by the study as food consumption limited to only starchy staples (majorly maize and millet) with oils and vegetables coming along less than once a week.

Despite the heavy reliance of rural households in northern Ghana on agriculture for their livelihoods, it is not clear how their production and consumption patterns are shaped by government agricultural support programs and interventions. Several studies have characterized household food production and consumption situations under various socioeconomic themes in Ghana, but little attention has been given to the contribution of the country's flagship agricultural subsidy program. This study adds to the literature by looking at how the structure of production and consumption is shaped by the GFSP.

2.3 Linkages between household agriculture, food security and nutrition

The World Food Summit (1996) defined food security as a situation where "all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and preferences for a healthy life". Food security is grounded on the pillars of food availability, access, utilization and stability. Adequate intake of acceptable range of foods is a necessary condition for proper nutrition, which is partly determined by individual biological factors. Likewise, FAO (2015) defines nutrition as "the intake of food, and the interplay of biological, social and economic processes that influence the growth, function and repair of the body". The result of nutrient intake in accordance with requirements and the body's ability to absorb and make use of these nutrients thus reflect the nutrition status of an individual (FAO,

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2015). Individuals' and households' ability to access food that meets nutritional requirements is therefore very essential.

Agriculture plays a very important role in ensuring food security and nutrition especially among rural households (Fan and Pandya-Lorch, 2012). As the main economic activity of most rural households in SSA, agriculture provides households with both physical and economic access to a range of foods that meet acceptable requirements for nutrition. The connections between agriculture, food security and nutrition are complex and intertwined. They border on food production, marketing, incomes (generation, availability and control) and gender roles and relations (FAO, 2017).

Theoretically, there are two main pathways through which household agriculture translates to quality consumption and in essence nutrition (Herforth and Harris, 2014). Firstly, through a direct pathway of production for own consumption (production-own-consumption pathway). Here, subsistence oriented agricultural households are hypothesized to boost their nutritional status by consuming a range of food items directly from their own farms (Masset et al. 2011; Du et al. 2015). An important factor of consideration in this pathway is the level of on-farm diversification. It is expected that the wider the range of foods produced, the wider the range consumed.

The second pathway, referred to as the income-food purchases pathway, occurs indirectly through production for income, and spending cash income on diverse food groups (Sibhatu et al., 2015). This pathway requires sufficient cash incomes, as well as an availability of and access/proximity to well-functioning markets (Nyantakyi-Frempong, 2017) that provide a large range of both food and non-food items, including healthcare to boost nutrition (World Bank, 2007).

This review shows that access to an acceptable range of foods for rural households could be directly from own production of those foods and/or market purchases from household incomes.

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Just like many SSA countries, rural Ghanaian households depend on agriculture for their food needs. However, the most dominant pathway from agricultural production to quality of food consumption is not fully explored and established. This limits policy options as to the most effective target and entry points to leveraging agriculture for improved nutrition and health. This study adds to the discussion by examining the influence of government support and other socioeconomic, market and production factors on incomes and production decisions (including crop diversification), and their implications for food consumption in the Upper West region of Ghana.

2.4 Impact of input subsidy programs on production diversification and income in SSA

Due to the close linkage between rural agriculture and households' food consumption, policy interventions targeting agriculture have potentials of influencing production decisions and outcomes, which go a long way to affect food consumption. Consistent with the subsistence pathway from household agriculture to food consumption, on-farm diversity is usually the production outcome of interest in nutritional studies. The income effects of these programs are also expected to contribute to household diet quality through an increased consumption of foods not produced at home by way of gains in purchasing power.

There are a number of cases of the impact of input subsidy programs on both crop diversification and agricultural incomes in SSA. Chibwana et al (2012) for example studied the effects of Malawi's Farm Input Subsidy Program (FISP) on land allocation to different crops and found that the program led to specialized farming systems. The study found that households allocated 16 percent more land to maize and tobacco which were the main targets of the program, and 21 percent less land to other crops including cassava and legumes. Holden and Lunduka (2010) had earlier reported a similar relationship between the FISP, tobacco cultivation and other crops. These two

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studies concluded that Malawi's FISP leads to simplified farming systems and acknowledged its potential negative implications on dietary diversity and quality. These findings were, however, contrasted by Kakwamba et al. (2012) and Snapp and Fisher (2015) who used nationally representative data to test the same hypothesis. The findings of Snapp and Fisher (2015) showed that the FISP was successful in increasing both the output of maize (by 27 percent) and on-farm diversification (by almost 30 percent). A study by Mason et al. (2013) in Zambia found similar results. They reported increases in land allocated to, and yields of the subsidy-biased maize, but observed that it did not influence area planted under other crops, although it had some spillover effects on the yields of other crops at quite small magnitudes. A study in Kenya also found an improvement in maize production due to the fertilizer subsidy program (Mason et al., 2015). Its impact on other farm enterprises was however not reported.

On incomes, Hossou et al. (2017) assert that there have been some impacts of FSPs in increasing the use of inputs, improving outputs and reducing poverty in the short and medium term in Zambia, Kenya and Malawi. However, as observed by Druilhe and Barreiro-Hurlé (2012), these improvements have not been convincing because FSPs continue to have problems, including poor distribution of benefits, targeting, design and implementation. In Malawi for instance, the FISP is reported to have contributed just modestly to household income (Ricker-Gilbert and Jayne, 2011). A similar situation is reported in Zambia by Mason and Tembo (2014) who found Zambia's FSP to impact positively on household incomes but not sufficient to avert the likelihood of falling into severe poverty. Mason et al. (2014) reported the effects of Kenya's FSP to be stronger than those of Zambia and Malawi because it is able to target and reach more resource-poor households.

This review provides an insight into the crop diversification and income effects of some government input subsidy programs in SSA. However, with the exception of Snapp and Fisher (2015), most of these studies do not advance their discussions to include the food consumption

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effects of the subsidized input-production interactions. For instance, despite the contribution of Ghana's FSP to improved food production, and an achievement of near food sufficiency, its role in influencing household diets by way of diversity and nutrient intake is not known. This study explored in detail the possible consequences of the production outcomes of FSPs on quality of household food consumption. Other factors including households' land and labour endowments, access to markets and physical infrastructure, household gender relations and institutional factors have all been reported to contribute to the production-consumption interaction, and hence were also considered in the analysis of this study.

2.5 Review of past studies on the relationship between household agriculture and dietary diversity/quality

Connections between household food production and quality of food consumed in general is evident and reported in many studies. For rural households with limited income and market access, hence highly dependent on own production for consumption, production diversification appears to be the best way to improve and maintain quality diets.

Using a cross-sectional survey and a multiple regression approach, Jones et al. (2014) for instance found farm production diversity to be very strongly associated with diet quality in Malawi. Similar findings were reported in Zambia and Nepal by Kumar et al. (2015) and Malapit and Quisumbing (2015) respectively. This relationship is especially important for households with limited market access for food purchases (Luckett et al., 2015; Romeo et al., 2016; Koppmair et al., 2017). These studies, however, assumed household agricultural production to be occurring exogenously and hence used a single step analysis to capture only consumption behaviors. Drawing from the theoretical underpinning of agricultural household model, the current study considered household production to be endogenous and occurring as a result of some household decisions. Households

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were thus modelled to first achieve a certain level of production based on some factors, before they choose a level of consumption. A two-step decision-making was therefore the starting point for analysis for this study.

Using a Two-stage Least Square regression approach to cater for endogeneity of household production, Hirvonen and Hoddinott (2017) reported that rural Ethiopian households needed to produce a wider range of food in order to improve the quality of diets of preschool children. A similar approach was used by Dillon et al. (2015) in Nigeria and their study found that production diversity was more powerful than agricultural income in determining dietary diversity. These studies addressed the major issue of endogeneity of household production in influencing food consumption. However, at the production stage, their focus was on biophysical and climate factors as drivers of crop diversification and incomes. Factors like temperature, altitude and rainfall volumes were the main factors considered to mediate household production and consumption. No consideration was given to the role of agricultural interventions and other institutional factors despite their potentials of affecting both crop diversification and incomes. The current study thus first modelled household production as a function of, among other things, a government input subsidy program, before advancing to its effects on food consumption.

Accounting for the role of input subsidies in these interactions, a study by Snapp and Fisher (2015) related Malawi's FSP to food consumption. The study found that the program contributed to diet quality through both increased levels of crop diversity and market purchases of other foods. However, the use of adoption of modern maize varieties under the FSP as a proxy for the income effect of the program (in the Snapp and Fisher 2015 study) may not be entirely accurate. Given that adoption is not an end in itself, farmers' adoption of improved varieties may not necessarily mean increased output and incomes. The current study bridged this gap by using the cash value of crop output (less cost) as a proxy to model the income effect of the FSP, and its subsequent

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consequence for diet quality. The study also considered other intervening factors in the food environment like proximity to markets and household dynamics including gender roles that affect food consumption.

In conclusion, agriculture plays an important role in the diets of rural households. The review above shows that agricultural production affects household diets through consumption from own production and through market purchases using farm income, which could be influenced by government interventions. Findings on the manifestation of these two pathways are however mixed, contextual and determined by many factors. In the case of Ghana, the relationships among the country's main agricultural intervention program, household production and quality of diets consumed are not empirically established. This study adds to the literature by assessing how production and consumption interactions in Ghana's Upper West region are shaped by crop-specific fertilizer subsidies and other factors.

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CHAPTER THREE

3.0 METHODOLOGY

3.1 Conceptual framework

Figure 1 presents relationships among Ghana's Fertilizer Subsidy Program (GFSP) and household food production and consumption behavior.

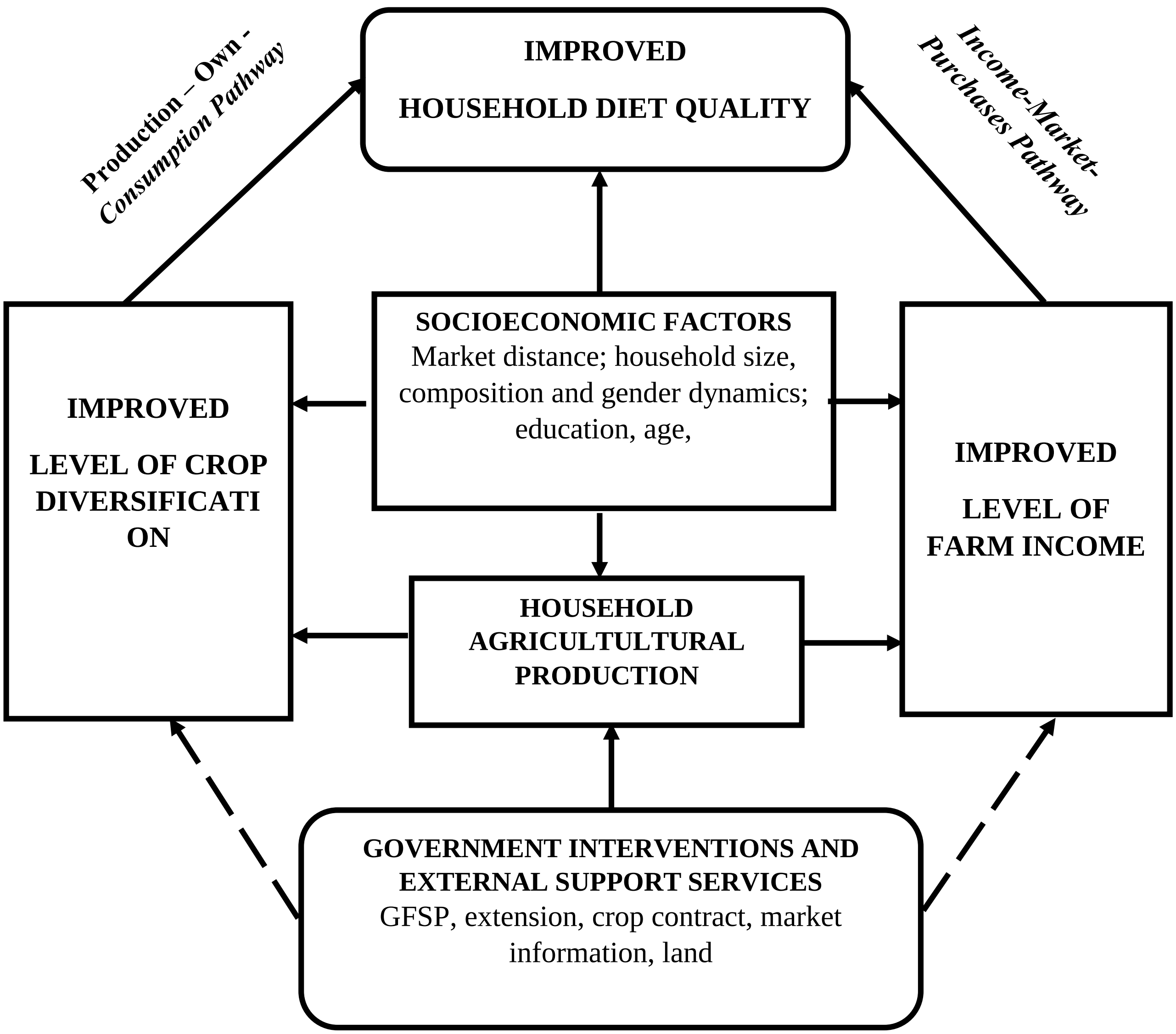

Figure 1: A Conceptual Framework showing relationships among the GFSP, crop diversification crop income and food consumption.

Source: Author's conceptualization

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This study conceptualizes that government programs and external support like the GFSP, access to extension services, market information and contract; household socioeconomic characteristics and endowments; and other production factors combine to determine the household's food production decisions and outcomes. These production outcomes subsequently interact partly with other interfaces including the market to determine the quality of household dietary intake.

Figure 1 depicts an illustration of the two broad pathways through which household agricultural production influences diet and nutritional diversity. The production-own consumption pathway is largely grounded on the household's level of diversification in production, whereas the income pathway depends on the level of farm income, and access to functional markets (Bhagowalia et al., 2012; Nantakyi-Frimpong, 2017). As advanced in Figure 1, the GFSP and other support services affect a household's level of crop diversification on one end, and farm incomes on another end. Through the subsistence (production-own-consumption) pathway, the level of crop diversification translates to quality diets by way of diversity in local availability. The assumption is that, the wider a household's range of foods produced, the wider their nutritional diversity. Similarly, an improvement in farm income also leads to quality consumption from market purchases of a range of foods that are not home-produced, through the income pathway.

Central to these production-consumption transmissions are other factors like access to markets and household socioeconomic characteristics and resource endowments. Some of these factors, apart from contributing to production decisions and outcomes independently, also influence the transition from production to consumption; or affect consumption on their own. For instance, on the production side, access to markets; household size and composition; and household gender roles could influence decisions like crop choices and their respective allocated sizes, which yield some levels of diversification and incomes. On the consumption side, access to and participation in markets serve as a source of both nutritional diversity and income, while household size and

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composition, including gender roles, determine food and income distribution decisions (including how much is sold/consumed at home), which by extension affect diet quality.

3.2 Theoretical framework

The study used an Agricultural Household Model, following Dillon et al. (2015) and Hirvonen and Hoddinott (2017). Here, a household is assumed to produce a range of output which is consumed and/or sold. The household uses fixed and variable inputs, some of which are purchased from the market.

In the standard formulation of the agricultural household model, a household's expected utility is maximized given the production function (q); an income constraint (P_i) and time endowment (E) (Strauss, 1984). Assuming perfect markets for all factors and products, a household's optimization problem is given by a structural model as follows:

$Max\ U\ (X_a, X_m, X_l,\ Z^h\ )$ ***Utility Function***…………………………………………….. (1)

Subject to:

$q(q_a, q_l, q_V, Z^q) = 0$: ***Production Function***………………………………………… (2.1)

$P_V q_V + P_m C_m = \ P_a\ (q_a - \ X_a) + \ P_l\ (l^s - q_l) + S$: ***Income constraint*** ………………. (2.2)

$l^s + \ X_l = E$: ***Time constraint*** ………………………………………………………….. (2.3)

Where $\boldsymbol{X_a}$ is consumption of a food product with price $\boldsymbol{P_a}$; $\boldsymbol{X_m}$ is consumption of manufactured good with price $\boldsymbol{P_m}$, $\boldsymbol{X_l}$ is consumption of leisure with price $\boldsymbol{P_l}$, $\boldsymbol{Z^h}$ is household consumption characteristics; $\boldsymbol{q_a}$ is production of a food crop with price $\boldsymbol{P_a}$, $\boldsymbol{q_l}$ is labor used in farm production with wage $\boldsymbol{P_l}$, $\boldsymbol{q_v}$ is other variable inputs used in production with price $\boldsymbol{P_v}$, $\boldsymbol{Z^q}$ is fixed factors in

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production and household production/producer characteristics; $\boldsymbol{l^s}$ is time worked **E** is total time endowment , **Y** is income and **S** is exogenous cash transfers.

To handle market failures associated with access to inputs and its resultant effects on production outcomes, most developing economies institute input subsidy programs to support and improve farmers' affordability of and access to production inputs. This enters the household's production function directly to influence output and profits, which subsequently determine the household's level of consumption. To account for these subsidy programs in the household model, the production function (q) of the household is transformed to include a variable ***F*** indicating a households' use of such government supported inputs. The production function (Equation 2.1) thus takes the form:

$q(q_a, q_l, q_V, Z^q, F) = 0$ (***Production function with government support***)……............. (2.1.1)

Solving the household maximization Problem begins with putting Equation (2.3) into (2.2) for the full income constraint:

$P_a q_a + P_m X_m - P_l X_l = (P_a\, q_a - P_l q_l - P_V q_V) + P_l E + S$ (***Full income constraint***) ….. (3)

which can be rewritten as:

$P_a q_a + P_m X_m - P_l X_l = \pi + P_l E + S$…………………………………………………… (3.1)

Where $\pi = P_a\, q_a - P_l q_l - P_x q_x$

Finding a solution to the model requires two steps.

The ***First Step*** involves solving the Producer problem for maximum agricultural profit given as:

$\pi^* = \pi^* \,(P_a, P_l, P_V, Z^q,\ F)$ ………………………………………………………........... (4)

Where P_a, P_l, P_V, Z^q are market, production and household characteristics that affect production/profit and ***F*** is a government agricultural policy tool, fertilizer subsidy in this case.

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The ***Second step*** involves maximizing the utility function (Equation 1) subject to the full income constraint (Equation 3.1). Doing this for a consumption good, say food commodity $\boldsymbol{X_a}$, the following reduced form demand equation is generated:

$$X_a = X_a[P_a, P_l, P_m, Z^h,\ \pi^*\ (P_a, P_l, P_V, Z^q, F),\ P_l E, S\ ] \ldots\ldots (5)$$

Where π^* is the level of profit (production outcome) already derived and presented in Equation 4.

From Equation (5), we represent the profit component: $\pi^*\ (P_a, P_l, P_V, Z^q, F)$ with $\boldsymbol{Y^*}$; and the rest of the expression: $P_a, P_l, P_m, Z^h, P_l E, S$ with $\boldsymbol{P}$ .This yields a final generic reduced form equation for consumption demand for commodity X given by:

$$X = X\,(P,\ Y^*) \ldots\ldots (6)$$

Where X is a given level of household consumption; Y^* is the household's optimum level of production (or farm profit), which is a function of other factors as shown in Equation (5); and P is a vector of other household and market characteristics affecting consumption.

The above illustration shows that, to solve the household maximization problem requires a two-step recursive approach, which involves solving the household production problem first before maximizing consumption, given the level of production/farm profit achieved in the first stage. In other words, a typical agricultural household first makes a production decision before maximizing utility by choosing a level of consumption based on the level of output or profit achieved.

3.3 Measuring production diversification and diet quality

3.3.1 Production diversification

Agricultural production diversification can be measured in a number of ways. Many studies have used different indicators; most of which are borrowed from the fields of ecology and biodiversity (Sibhatu et al., 2015). Production diversification can be captured as a simple count of crops, and

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in some cases, livestock enterprises, in which a household is engaged (Agyeman et al., 2014; Jones et al., 2014; Sibhatu et al., 2015; Kumar et al., 2015). These measures are used to capture specie richness in ecological studies and it gives an opportunity to easily identify differences among farms and farming strata (Sibhatu et al., 2015). Production diversification may also be measured by the proportion of land or acreage allocated to specific crops, or particular crop groups (Winters et al., 2006; Chibwana et al., 2012). Similar to this, some studies have captured it using categorical indicators of crop groups a household produces, without necessarily considering land allocations in terms of quantity (Aneani et al., 2011; Kumar and Singh, 2016). These indicators also have an advantage of gaining insights, particularly into agricultural land use under different enterprises. However, it does not give enough information on specie richness.

To have the combined advantage of evenness (distribution of area cultivated across crops produced) in addition to specie richness (by count), diversification indexes such as the Simpson's Index, Margalef Species Richness Index, Herfindalh Index and the Composite Enthropic Index can be used (Joshi et al., 2004, Jones et al., 2014; Mufyoka-Mukuka and Kulghatz, 2014; Seng, 2014). These indexes, although differing in computation, follow a similar logic: that is, in addition to the crop count (specie richness), they also factor the proportion of total land area allocated to each of the crops (evenness) in its computation. As such, these measures provide important dimensions, which may be lost in the alternative use of simple count or land allocation indicators. This study used the Herfindahl Index (HI) because it has the advantage of giving a standard scale for accessing the level of diversification (Pal and Kar, 2012).

Crop Diversity Index (CDI) – from the Transformed Herfindahl Index (THI)

Following Meena et al. (2016), the Herfindahl Index (HI) is computed as a product of the number of crops produced by a household and the sum of squares of the share of land allocated to each crop out of total cropland. It is given mathematically as:

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HI = $\sum_{i=1}^{N} P_i^2$ …………………………………………………………………………. (7.1)

Where N = the total number of crops produced by a given household, and P_i is the proportion of land allocated to the *ith* crop out of total cropped area. The index is bounded between 0 and 1. Originally, the Herfindahl Index is a measure of concentration, such that "1" represents complete concentration/specialization and "0" represents complete diversification.

For direct interpretation relating to diversification rather than concentration, a Transformed Herfindahl Index (THI) is generated by subtracting the Herfindahl Index (HI) from 1, following Malik and Singh (2002) as shown below

THI = 1 – HI ………………………………………………………………………….. (7.2)

Still bounded between 0 and 1, the THI in this case considers "0" as complete specialization, and "1" as complete diversification. Diversification therefore increases as the index approaches 1. For simplicity, this index is referred to as ***Crop Diversity Index (CDI)*** in the rest of the study.

3.3.2 Household diet quality

Food Consumption Score (FCS)

The complexity and multidimensionality of food security emanating from its pillars of food availability, accessibility, stability and utilization, make it difficult to be captured in a single indicator. There are, however, several acceptable proxy indicators including the Household Dietary Diversity Score, Food Consumption Score, Household Hunger Scale, Household Food Insecurity Access Scale and the Food Variety Score. For this study, the Food Consumption Score (FCS) developed by WFP (2008) was used to measure diet quality. The FCS is a measure of food security, which in addition to frequency of consumption, also takes into account diversity and the relative nutritional importance of a given range of food groups. The FCS is computed by assigning weights to different food groups based on their nutrient content, and multiplied by the number of

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days in a 7-day recall period, that a household consumed one or more items from that food group. Foods with relatively higher energy, good quality protein and a wider range of easily absorbed micronutrients are given the highest weights (WFP, 2008).

Frequency of consumption as used in this computation refers to the ***number of days*** within the 7-day recall period that a specific *food group* was consumed. Therefore, the maximum frequency that can be recorded by a household for any food group is seven (7). Frequency of consumption and weight assignments are also restricted to ***food groups*** rather than food items. Thus, for example if one food item, say wheat is consumed three days in the recall period, and another food item in the same food group (cereals), say maize is eaten every day, the frequency score of that food group will be seven.

Following the explanations above, the basic equation for computing the FCS in this study is given as:

$FCS = \sum_{i=1}^{N} \alpha_i \beta_i$ ……………………………………………………..………………... (8)

Where N = the total number of food groups that a given household consumed from.

α_i = Nutritional weight assigned to food group *i*.

β_i = number of days of consumption of food from food group *i*.

Table 1 gives a breakdown of the major food items and food groups used in computing the FCS, their assigned weights and the justification for the weight assignment as provided by WFP (2008).

Table 1: Food groups, weights and weight justifications for computation of the FCS

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Food Items	Food groups	Weight	Justification
Cereals: Maize, rice, sorghum, millet, bread **Roots/Tubers:** Cassava, yams, potatoes, plantains	Staples	2	Energy dense; protein content lower and of poorer quality than legumes; micronutrients are bound by phytates
Nuts, Beans, Peas, Seeds	Pulses	3	Energy dense; high amounts of protein but of lower quality than meats; micronutrients inhibited by phytates; low fat
Vegetables (including edible leaves)	Vegetables	1	Low energy; low protein; no fat; high micro-nutrients
Fruits	Fruit	1	Low energy; low protein; no fat; high micro-nutrients
Animal Proteins: Meat, eggs and fish	Meat and fish	4	Highest quality protein; easily absorbable micronutrients (no phytates at all); energy dense; fat. Even when consumed in small quantities, improvements to the quality of diet are large
Milk/Milk Products	Milk	4	Highest quality protein; micronutrients; vitamin A; and energy.
Sugar and sugar products, honey	Sugar	0.5	Empty calories. Usually consumed in small quantities.
Oils, fats and butter	Oil	0.5	Energy dense but usually no other micro-nutrients. Usually consumed in small quantities

Source: World Food Program (2008)

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Diet diversity indicators, although not ultimate measures of nutrition, have been found to positively correspond with various acceptable nutrition indicators such as measures of anthropometry (Ruel, 2003; Moursi et al., 2008; Pellegrini &Tasciotti, 2014) as well as adequate energy and nutrient intake (Steyn et al., 2006; Jones et al., 2014). The Food Consumption Score is thus a good indicator of diet quality in nutritional studies.

Applying the FCS, the weighted scores from Equation (9) provide a basis for categorization of households, with the cut-off points shown in Table 2.

Table 2: Cut off points for food consumption categorization

FCS range	Food Consumption Category
0 to 21	Poor Food Consumption
21.5 to 35	Borderline Food Consumption
35.5 and above	Acceptable Food Consumption

Source: World Food Program (2008)

Both the weighted scores (FCS) and consumption categories were used to explore different aspects of interest to the study.

3.4 Empirical data analysis

The aim of this study was to assess the effects of Ghana's FSP on crop diversification and incomes, and their subsequent relative implications for household diet quality. These were achieved by the use of descriptive statistics and econometric approaches.

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3.4.1 Objective 1: Comparison of the structure of food production and consumption between participants and non-participants of the Fertilizer Subsidy Program

Descriptive statistics including means and percentages were used to describe socio-economic and demographic characteristics of respondents. Independent t-tests (for continuous variables) and chi square tests (for categorical variables) were used to establish whether the means/proportions of all production and consumption outcomes are the same between GFSP participant households and their non-participant counterparts. A non-significant t-test/chi-square value indicated no statistically significant difference between the means/proportions of the two groups, while a significant t-test/chi-square value indicated statistically significant differences. For each variable considered, the null hypothesis that there is no difference in means/proportions between the two groups was rejected if the t-test/chi square value is not significant. Aspects of agricultural production, including crop diversification; commercialization and income from crop sales; as well as food consumption patterns were analyzed.

Gross margin analysis was also done to compare the gross benefits achieved from alternative crop enterprises. By this, the direct costs of producing each crop or crop group were determined, and the total monetary value of output for each crop/crop group also computed. The benefits/gains (gross margins) derived from producing alternative crops were thus given by:

$$GM_{ij} = TR_{ij} - VC_{ij} \quad \ldots \quad (9)$$

Where TR_{ij} = total cash value of output from the *jth* crop enterprise to the *ith* household, and

VC_{ij} = the direct variable cost the *ith* household incurs in producing the *jth* crop output.

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3.4.2 Objectives 2 and 3: The effects of GFSP on crop diversification and income, and their implications for household diet quality

In analyzing the role of the GFSP and other factors in influencing households' extent of crop diversification and income, and their subsequent effects on household diet quality, a three-step Endogenous Treatment Regression Model was used.

Picking up from Equation (6) of the theoretical model, a typical agricultural household chooses a level of consumption based on a level of production earlier achieved. Thus, the household problem involves two stages of first making production decisions before choosing a level of consumption. A natural starting point of empirical analysis is therefore a two-stage approach as shown below:

$$Y^* = Y(W) \quad \text{…………} \quad (10)$$

$$X = X(P, Y^*) \quad \text{…………} \quad (11)$$

Where Equation (10) is the first step production problem and Equation (11) is the consumption equation (second step).

From Equation (10), the production maximization problem is a function of factors including access to or otherwise of a government agricultural intervention program, which in this study is the GFSP. However, since not all households accessed inputs from the program in the season under study, there is a potential selection bias. This could arise from the fact that households' access to inputs under the program is not random, hence not completely observed. Access is only observed for participating households. Another possible source of selection bias is that there could be unobserved factors affecting production that could also affect participation in the GFSP. Thus, using a dummy variable of this nature as a regressor could create endogeneity problems arising from self-selection bias. To solve the selection bias problem, access to or otherwise of GFSP inputs must be modeled first; giving rise to a third equation. Following Jumbe and Angelsen (2006), the

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empirical model is specified as a system of simultaneous equations to account for the interrelationships among access to GFSP inputs, farm production, and household diet quality as follows:

$F_i = \gamma Z_i + \varepsilon_i$ ***(Access to GFSP inputs - first step)***……………………………………... (12.1)

$Y_i = \alpha F_i + \delta W_i + \mu_i$ (***Farm production - second step***)………………………………… (12.2)

$X_i = \beta Y_i + \psi P_i + e_i$ (***Food consumption – third step***)……………………………….... (12.3)

Where, F_i is access to GFSP, captured as a dummy variable indicating whether or not a household received inputs from the GFSP in the 2017 planting season; Y_i denotes the level of farm production; and X_i is the level of household food consumption. The vectors Z_i, W_i and P_i represent exogenous factors hypothesized to affect access to the GFSP, production outcomes and diet quality respectively. The unknown parameters to be estimated are γ, α, β, δ and ψ; while ε_i, μ_i and e_i represent error terms of the respective equations.

It must be noted that in this empirical estimation, the farm production outcomes of interest were either crop diversification (measured by the CDI) or crop income (measured by the monetary value of total crop output). Following Dillon et al. (2015), these will be used alternately in models estimating the production Equation (12.2), and subsequently, their alternative implications for consumption in Equation (12.3). This allows a disaggregation of the two pathways linking farm production to consumption, as discussed in the conceptual framework. Crop diversification is a proxy for the production-own-consumption (subsistence) pathway and farm income represents the income-food-purchases pathway. The 3-equation model shown above was estimated in three systematic steps as follows:

The first two steps used an endogenous treatment regression model as a self-selection bias correction procedure (Heckman, 1979). Doing this, Equations 12.1 and 12.2 are first modeled

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together. The first step (Equation 12.1) aims at obtaining the inverse Mills' ratio to correct the selection bias in the estimates of crop diversification/income (Equation 12.2).

From Equation 12.1 (the GFSP equation), the following reduced form equation is specified:

$$F_i = \begin{cases} 1 \; if \; F_i^* > 0 & Received \; inputs \; from \; the \; GFSP \\ 0 \; if \; F_i^* = 0 & Otherwise \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(13)}$$

A binary probit model was applied in this first step because the dependent variable, access to GFSP (F_i) was binary; coded as one (1) and zero (0) for “yes” and “no” responses respectively.

Solving Equations (12.1) and (12.2) together, the error terms ε_i and μ_i are each assumed to have a bivariate normal distribution structure with mean zero and the following covariance matrix (Heckman, 1979): $\begin{pmatrix} \sigma & \rho \\ \rho & \sigma \end{pmatrix}$. Awareness of the Planting for Food and Jobs (PFJ) program and access to tarmac road were used to correctly identify the probit equation.

The second step (Equation 12.2) aims at obtaining the predicted estimates of the production outcomes of interest. Applying the ordinary least squares (OLS) directly to Equation (12.2) yields inconsistent estimates of the crop diversity (CDI) or income. This is because the expected value of the error term μ_i, conditional on access to GFSP fertilizer is non-zero. This implies that the conditional mean of crop diversification (or income) in Equation (12.2) is given by:

$$E(Y_i \mid F_i) = \delta W_i + E(\mu_i \mid Z_i, \varepsilon_i) = \delta W_i + E(\mu_i \mid \varepsilon_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(14)}$$

such that $E(\mu_i \mid \varepsilon_i) \neq 0$. From here, the conditional expectation of the error terms μ_i and ε_i is given as:

$$E(\mu_i \mid \varepsilon_i) = E(\mu_i \mid \varepsilon_i \leq \gamma Z_i) = E(\sigma_u, \rho | \varepsilon_i) = \rho \sigma_\mu \frac{\infty (\gamma Z_i)}{\Phi(\gamma Z_i)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \text{(15)}$$

Where ∞ (.) and Φ (.) are respectively the standard normal density and cumulative distribution functions. From Equation (15), $\boldsymbol{\lambda_i} = \frac{\infty(.)}{\boldsymbol{\Phi}(.)}$ can be computed and defined as the inverse Mills' ratio,

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which represents the covariance between residuals of the treatment equation (access to GFSP) and the outcome equation (crop diversification or income).

Equation (12.2) can now be re-specified by replacing $E(\mu_i \mid \varepsilon_i)$ with the inverse Mills' ratio $\boldsymbol{\lambda_i}$ as a term for correcting self-selection bias as shown below:

$$Y_i = \alpha F_i + \delta W_i + \theta \lambda_i + \eta_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(16)}$$

Where η_i is the assumed error term with the conditional mean of zero (0) and variance σ_η^2; and θ is an unknown coefficient of λ. Evidence of self-selection bias is confirmed if the coefficient of the inverse Mills ratio, i.e. θ, is statistically significant.

The second hypothesis that the GFSP has no effect on crop diversification and income was tested individually. *This hypothesis was rejected in a situation where the coefficient estimate of GFSP in the alternative models of Equation 16 was statistically significant.*

Having successfully solved steps 1 and 2 to address sample-selection bias, and estimated the equation for household production, the third step estimates the implications of the production outcomes of interest (crop diversification and income) and other factors on household diet quality measured by the Food Consumption Score (FCS). This third step accounts for the fact that, in a household model, agricultural production does not affect food consumption exogenously (Dillon et al., 2015; Hirvonen and Hoddinott, 2017). Following Jumbe and Angelsen (2006), predicted values of production outcomes are generated from Equation (16) and denoted by $\widehat{Y_\iota}$ and put into the consumption equation. The consumption Equation (12.3) is thus re-specified by replacing Y_i with $\widehat{Y_\iota}$ as one of the explanatory variables as follows:

$$X_i = \beta_0 + \beta_i \widehat{Y_\iota} + \psi P_i + e_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(17)}$$

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The dependent variable in Equation (17), X_i is diet quality, measured by the FCS. It is a continuous variable and therefore Ordinary Least Square (OLS) technique was used to estimate the equation. The parameter β_i is the coefficient of production outcomes of interest, $\widehat{Y_i}$ (predicted values of crop diversification or income in alternate models of Equation 17), and ψ is a vector of parameters of all other factors (vector P_i) hypothesized to influence household diet quality.

The third hypothesis that crop diversification and income gains from the GFSP do not influence diet quality was rejected for each of the variables tested individually if their respective coefficient estimates in the consumption model (Equation 17) were statistically significant.

3.5 Description and justification of model variables

The choice of the explanatory variables for this study was guided by extensive literature review of past studies relating to household food production and consumption behaviors. The variables under description in this section are grouped into those which are exclusive to the production model, those which affect both production and consumption, and those that are exclusive to the consumption model. Expected outcomes of variables included in the model for crop diversification and income are respectively shown in columns 2 and 3; and that of consumption in column 4 of Table 3.

Access to GFSP inputs: this was hypothesized to affect the degree of crop diversification negatively. Farmers who use government's subsidized fertilizers are less likely to diversify off the preferential cultivation of GFSP supported crops and fertilizer-responsive crops (Snapp and Fisher, 2015). Also the inclusion of maize seeds in the subsidy package is very likely to lead to a predominantly maize farming system as found by Chibwana et al. (2012). However, a positive effect of GFSP is expected on crop income. Subsidized fertilizer use in SSA has been found to

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boost crop output and profits (Houssou et al., 2017). Therefore this was hypothesized to have a negative effect on diversification but a positive effect on farm income.

Table 3: Expected signs of regressors included in the model

Variables	**Production**		**Consumption**
	Crop Diversification (CDI)	Crop Income (Value of output)	Food Consumption Score (FCS)
Access to GFSP inputs (1=Yes; 0=No)	-	+	
Distance to market (km)	-/+	+	-
Crop contract (1=Yes; 0=No)	-	+	
Access to market information (1=Yes; 0=No)	+	+	
Total land size (acres)	+	+	
Extension frequency (number)	+	+	
Years of farming (number)	+	+	
Relative household subsistence requirement (index)	-	-	
Regular HH labor size (number)	+	+	
Female involvement in agricultural decisions (1=Yes; 0=No)	+	-/+	+
Number of non-agricultural income sources/non-farm income (number)	-	-	+
Crop diversity index (CDI)			+
Crop income (Value of total crop output)			+
Years of formal education(number)			+
Total household Size(number)			-
Agriculture as main economic activity (1=Yes; 0=No)			+

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Land size: This is captured as the amount of land in acres[1] cultivated by a household. This factor was hypothesized to influence both crop diversification and income positively. It is expected that the bigger the size of a household's land available for farming, the higher the possibility of the household producing a range of crops. Output and commercialization are also expected to be high with larger scales, hence higher incomes. Similar findings have been reported by Joshi et al. (2004), Seng (2014) and Mandal and Bezberuah (2013).

Access to market information and frequency of extension: Farmers who have access to information and extension services are more likely to diversify production (Joshi et al., 2004). Access to these factors are also likely to increase farm incomes (Agyeman et al., 2014). Access to information, through social, print or mass media and any other reliable sources, as well as frequent contact with extension services could expose farmers to opportunities, including technologies that could contribute to better farming outcomes, including diversification and higher outputs for increased incomes. A positive relationship was expected between these factors for both crop diversification and incomes.

Crop Contract*:* Captured as a dummy to indicate whether a household has any form of contract with the buyer of any crop or not, this variable was hypothesized to influence crop diversification negatively but incomes positively. Households which have contract for a particular crop enterprise are likely to produce more of the "contract crop" at the expense of others. A positive relationship with crop income is however expected due to the ready market and the likely commercial orientation of such households.

Regular household labour size: This was measured as the number of household members regularly available for farm work. It was used in the study as an indicator of household labour and it was hypothesized to affect both crop diversification and incomes positively. Households with a

[1] 2.5 acres = 1 hectare

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larger pool of regularly available labour can spread their labour resource across a wider range of enterprises for both diversified output and higher incomes (Culas, 2006).

Household relative subsistence requirement: This variable is computed as the ratio of a household's caloric requirement (with respect to household size, age and gender composition) to their land endowment. A negative relationship was expected between this variable and both diversification and income. This is because a household which has a higher relative subsistence requirement is likely to dedicate more land to the production of basic staples (Chibwana et al., 2012) to meet basic home consumption. A negative effect on income is also expected because households with higher subsistence requirement are likely to produce more subsistence-oriented crops, and a greater proportion of it will be consumed at home rather than sold for income.

Distance to market: this variable could affect diversification decisions and incomes either negatively or positively. For market-oriented households, proximity to market may come with positive implications for specialization and commercialization (Hlongwane *et al.* 2014); and incomes (Ibrahim, 2009). This effect could however be positive for crop diversification in some situations. The farther away food markets are, the more likely it is for households to diversify their production to meet their food needs, and vice versa (Koppmair et al., 2017). For consumption, proximity to market is expected to offer easy access to a wide range of non-home-produced foods (Jones et al., 2014), hence a positive effect is expected on diet quality.

Female involvement in household agricultural decisions: This was hypothesized to have a positive influence on crop diversification but indeterminate for income. Women are more likely to have home consumption in mind when making production decisions, hence will produce more crops to make up a more diverse home diet if they have a say in production decisions. Similarly, they are more likely to produce more crops with subsistence value than those with market value (Githinji et al., 2014), and hence could influence farm incomes negatively. A positive effect was

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however expected for diet quality if women have an input in agricultural decision making. This is because, in addition to their consumption-oriented nature, it has been found that when women have some control over sales decisions, farm incomes are more likely to improve household welfare (Jones et al., 2014). This variable was measured as a dummy with “1” representing a household where the primary woman has sole or joint control over production and sales decisions, and “0” otherwise. Thus “0” represents a situation of complete male dominance in agricultural production and sales decisions.

Number of off-farm income sources: This variable was hypothesized to influence both diversification and crop incomes negatively. Households that have a range of income sources are less likely to prioritize agriculture in general, for both food and income. However, it can affect food consumption positively. Off-farm income provides a good compliment to farm income for all household expenditures (Koppmair et al., 2017). Also, it is usually associated with a more frequent flow of income, which could have positive implications for consumption.

Years of formal Education of Household Head: This was hypothesized to influence diet quality positively as found by Dillon et al. (2015). Highly educated household heads are likely to be aware of the nutritional value of food, hence likely to prioritize quality meals for the household. They may as well have access to incomes high enough to facilitate a higher level of consumption.

Agriculture as the household’s main livelihood activity: This was measured as a dummy variable with “1” representing households whose number-one economic activity is agriculture, and “0” is for otherwise. It was included in the model to ascertain how the main livelihood activity in the region is related to food consumption. Considering the close linkages between agriculture and food consumption in a rural setting, a positive relationship was expected between this variable and diet quality.

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Crop diversification and crop income: Crop diversification and crop income were hypothesized to positively affect quality of household diets. Diversified crop patterns are expected to be directly related to dietary diversity in a predominantly subsistence context like the one under study. Similarly, income gains from agricultural production are expected to boost the consumption of other food groups not produced at home through its income effect (Sibhatu et al., 2015).

For each of the variables described and discussed above, the null hypothesis that they have no influence on their respective outcomes was rejected if their coefficient estimates were statistically significant.

NB: For all hypotheses tested in this study, P values were used to determine the statistical significance of any relationships or comparisons. The null hypotheses in all the tests undertaken were rejected if the corresponding P values to the estimates of any variable is less than the standard significance levels of 1 percent, 5 percent and 10 percent.

3.6 Description of the study area

The Upper West region is located at the north-western corner of Ghana. It is located in the Sudan Savanna agro-ecological zone of the country with a single rainfall pattern (spanning from May to November). Being predominantly rural (84 percent), agriculture is the main livelihood activity in the region: supporting 92 percent of residents (GSS, 2013). Major food crops grown include maize, sorghums, beans and groundnuts. Fowls, guinea fowls, cattle, pigs and sheep comprise livestock production. Seven out of every ten people in the region live below the poverty line (GSS, 2014), and households have generally poor welfare indicators including literacy rates. Physical infrastructure is also poor and limited (Malapit and Quisumbing, 2015).

Figure 2 below presents a map of the Upper West region showing the study districts.

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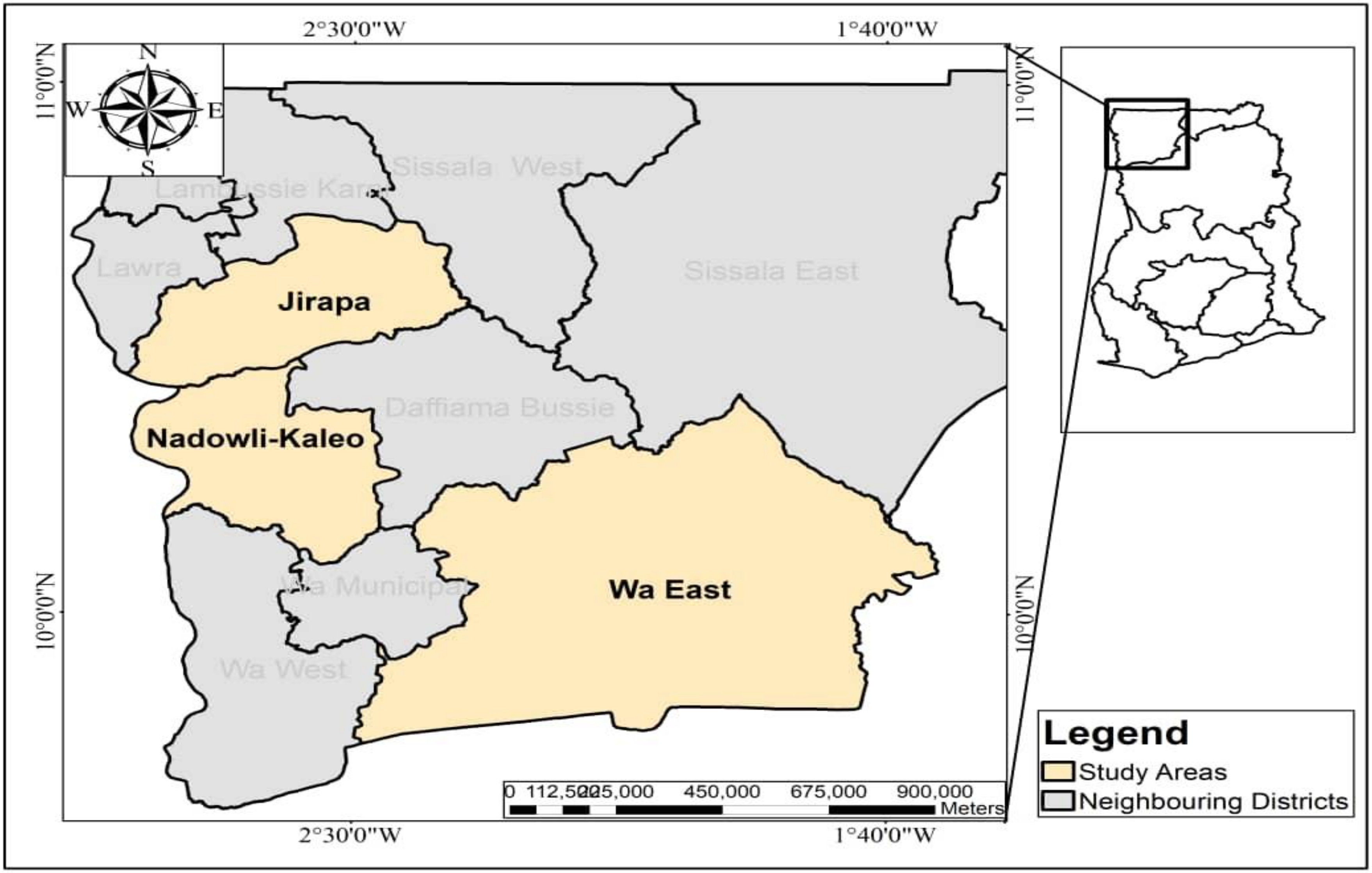

Figure 2*: A map of the Upper West region of Ghana showing the surveyed districts*

Source: Department of Geography and Regional Planning, University of Cape Coast - Ghana (2019)

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The region lies in the agro-ecological zone with the highest rate of fertilizer use in Ghana (Fearon et al., 2015), and is a major target for the Fertilizer Subsidy Program (Mustapha et al., 2016). It is one of the regions with the most malnourished people, with very poor food intakes (Hjelm and Dasori, 2012). The regional stunting rate is 23 percent; prevalence of child anemia is 73 percent.

3.7 Sampling procedure

A sampling procedure involving three stages was used to select respondents. In the first stage, the Upper West region was purposively selected because of its high rural population. It is also one of the regions with the poorest food intake and highest prevalence of malnutrition; and it falls in the Guinea savanna agro-ecological zone, which is a priority target zone of the GFSP. In the second stage, three districts in the region, namely, Nadowli, Jirapa and Wa East were selected because of their predominantly rural populations, with agriculture as their main livelihoods. A high rural population was relevant to this study because of the close linkage between rural livelihoods and agriculture and food consumption. Again, the high probability of rural households' dependence on agriculture for all their food needs was very important. In the third stage, with the help of respective district assembly and agricultural officers, various villages within the selected districts were visited and respondents selected using a systematic random sampling technique to ensure there is no bias. For each village visited, the criterion for the systematic random sampling approach was based on the village population details and settlement patterns provided by the village chief. The target population of this study was agricultural households in the selected study sites. The final sample size for the study was 247 households. The sample size was justified by budget and physical constraints. It is as well identical to those used by some previous studies that attempted to relate agricultural diversification and income to diets in SSA (For example Babatunde and Quaim, 2010;

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Otabil, 2016; de Jager et al., 2017). The respective proportionate share of each of the three districts in the total sample size was determined based on their population statistics as shown in Table 4.

Table 4: Sample size distribution across the sampled districts

District	Household Population	Sample Size	Share in total sample size
Nadowli	15210	94	38
Jirapa	13911	86	35
Wa East	10768	67	27
Total	39899	247	100

Source: Ghana Statistical Service (2013)

3.8 Data needs and data collection methods

Primary data were used for the study. Semi-structured questionnaires were used to collect data on the fertilizer subsidy program; household and community characteristics; agricultural support services; and food production, marketing, and consumption. The questionnaires were first pretested and later administered to respondents in face-to-face interviews. A semi-structured questionnaire and face-face design was adopted because these allowed enumerators to better explore responses they received, seek clarifications and probe respondents for more accurate responses.

Prior to finalizing the design of the questionnaire, three Focus Group Discussions (FGDs)): one in each district, were conducted. This was done to get deeper understanding of crop production and marketing; and household food consumption dynamics in the region. Useful information on general dietary patterns and composition, and intra household food allocation were obtained from here. Household gender roles, particularly on agriculture and income decisions, and their implications for household consumption were also discussed. Each of the three FGDs were made

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up of 15 people (8 males and 7 females). The discussion on women roles and intra-household consumption dynamics was restricted to females.

Key Informant Interviews (KII) of persons from the regional office of the Ministry of Food and Agriculture (MoFA); the nutrition department of the regional office of the Ghana Health Service (GHS); and village chiefs were also conducted. Information from these interviews was used to get a deeper understanding of the study area regarding the GFSP; socio-cultural production and consumption practices and beliefs; foods with special nutritional values consumed in the region; community assets and facilities and gender relations. Insights from both the FGDs and the KIIs were useful in designing the questionnaire for data collection. These insights helped to capture the ideas, feelings and opinions of respondents, and also contributed to understanding and interpreting findings and results from the study.

3.9 Diagnostics tests

Multicollinearity

Multicollinearity occurs when there is correlation between independent variables in a model (Greene, 2009). The Variance Inflation Factor (VIF) and the Pearson pairwise correlation matrix were used to test for multicollinearity. According to Gujarati (2004), any variable with a VIF greater than 10 demonstrates presence of Multicollinearity. Similarly, a Pearson correlation coefficient of 0.5 or above could mean high collinearity. Results for this test showed that there was no multicollinearity since no variable had a VIF greater than or equal to 10, the mean VIF for the production model was 1.42, and those of the consumption models were 1.23 and 1.21. Results of these tests are shown in appendix 2 and 3 respectively.

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Heteroscedasticity

Heteroscedasticity occurs when the variance of the error term is not constant (Wooldridge, 2010). Following Wooldrige (2010), Breusch-Pagan test was used to detect if the variance of the error term was constant. Results of the test for the production model was chi^2 (1) =1.89 at Prob > chi^2 = 0.1779; and that of the final stage consumption model was chi^2 (1) =1.62 at Prob > chi^2 = 0.2024, meaning there was constant variance across the error terms in both models, indicating the absence of heteroscedasticity.

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CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Household socioeconomic characteristics

Results in Table 5 present descriptive statistics such as means and percentages, which were used to analyze the socioeconomic and institutional characteristics of agricultural households in the Upper West region of Ghana

Table 5: Socioeconomic characteristics of households

Variables (N=247)		Means/percentages
Age of household head (years)		55.9 (13.8)
Number of years of formal education of household head		2.0 (4.29)
Household Size		9.6 (4.89)
Dependency ratio		1.41 (1.02)
Total annual household income (GH₵)		5320.72 (2925.8)
Household income per capita (GH₵)		625.86 (370.97)
Land size (acres)		8.03 (3.99)
Distance to nearest market(kilometers)		10.84 (7.73)
Cost of Transportation to nearest market (GH₵)		1.80 (1.42)
Gender of Household head (% Male)		90.00
Access to tarmac roads (to nearest market) (% Yes)		30.00
Contract for crop sales (% Yes)		17.00
Access to market information (% Yes)		68.00
Access to Fertilizer Subsidy Program (% Yes)		70.00
Mode of Land ownership/access :	*Inherited* (% Yes)	54.00
	Permission from chief (% Yes)	6.00
	Family land (% Yes)	40.00
Main Outlet for crop sales:	*Farm gate* (% Yes)	69.00
	Local market (% Yes)	32.00

Note: 1 USD($) was equivalent to Ghana Cedis (GH₵) 4.7 at the time of the survey.
The figures in paranthesis show standard deviations

Source: Survey Data (2018)

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As shown in Table 5, most (90 percent) of the households were male-headed. This is typical of communities in Northern Ghana where major household decisions on agricultural production and marketing are made by men (Nyantakyi-Frimpong, 2017). The Ghana Living Standards Survey (GSS, 2014) also shows that households in the rural savanna agro-ecological zone have the highest proportion of male-headed households.

The average number of years of education of heads of respondent households was 2. This implies that most of them had almost no formal education. This is consistent with Ghana's Population and Housing Census (GSS, 2013), which reported that over 60 percent of people in the Upper West region are not literate. This could be linked to the age of household heads, which is 56 years on the average for this sample. As of 1995, just about 20 percent of all adults in the Upper West region had some form of formal education (GSS, 1995); indicating low school enrollment over the past years.

Household dependency ratio, a measure of the household's non-economically active population relative to its economically active ones, was 1.4. This high average ratio could be partly attributed to the massive out-migration of economically active people in the region. The Ghana Living Standards Survey (GSS, 2014) observes that the Upper West region has one of the largest number of migrants to Southern Ghana in pursuit of jobs, leaving a large number of dependents behind.

On average, households cultivated about 8 acres of land, and access was predominantly by way of individual ownership through inheritance (54 percent), joint extended-family ownership (40 percent) and through permission from chiefs/Tindana (6 percent). This is consistent with Anaglo et al. (2014) who observed that over 90 percent of land tenure in the Upper West region is largely based on customs and family ties.

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Average household income was GHC 5320, with household annual per capita income at an average of GHC 625. This translates to approximately GHC 2 (USD 0.5) daily per capita income, which represents a situation of high poverty rates based on the global poverty line of USD 1.9. According to the Ghana Living Standards Survey (GSS, 2014), 7 out of every 10 people in this region are poor. More so, the CFSVA of Northern Ghana mentioned agricultural households as one of the poorest livelihood groups (Hjelm and Dasori, 2012).

Northern Ghana, including the Upper West region, is one of the major target regions of Ghana's Fertilizer Subsidy Program (GFSP). Findings from this study indicate that households' access to the GFSP is high and encouraging. About 70 percent (i.e. 173) of the households had access to inputs from the program, with 74 (30 percent) otherwise. This is in contrast with some previous studies who found relatively lower access to the GFSP in Northern Ghana (for example 43 percent by Mustapha et al., 2015 and 64 percent by Imoru, 2016). However, this finding is not surprising considering the favorable changes that were made in the program in the season under consideration in this study (2017). This includes an increase in the subsidy rate from a previous 12.5 percent to 50 percent; and the introduction of a more flexible payment plan (RoG, 2018). Also, the region is a priority target of the GFSP (Mustapha et al., 2016) and it lies in the agro-ecological zone with the highest fertilizer use in Ghana (Chapoto and Ragasa, 2013; Fearon et al., 2015). These factors explain the large disparity in the percentage of households who participated in the program as against non-participants.

Average distance to market among households was about 11 kilometers. Proximity to market is very important for both output sales and food purchases. However, an average distance of 11 kilometers reflects a state of limited market infrastructure in the region. In fact, less than 30 percent of the respondent households accessed markets within a 5 kilometer radius. Similarly, only about

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30 percent of all households had access to tarmac roads leading to the nearest market. These findings confirm the extremely limited and poor state of market, road and general infrastructure in the Upper West region and Northern Ghana at large (Malapit and Quisumbing, 2015). These conditions give rise to an average cost of about GH₵1.80 (USD$ 0.40) on transportation in accessing the nearest market. This could have dire implications, particularly for food purchases, with an average daily per-capita income of about GH₵ 2 (USD$ 0.5).

The results as well showed that farm gates and local markets are the main outlet for most crop sales. Close to 70 percent of households reported selling their output at the farm gate and the rest at the nearest local markets, with only 17 percent of households having some contract with buyers.

4.2 Objective 1: Comparison of the structure of food production and consumption between participants and non-participants of the GFSP

4.2.1 Household crop production

4.2.1.1 Crop types

Figure 3 shows the various crop enterprises households are engaged in, and their respective shares in households' total land under cultivation. The most dominant crop enterprise was maize, with 96 percent of households producing and about one third of all household cultivated land allocated to it. Other major crops include groundnut and cowpeas which were produced by 87 percent and 84 percent of the respondent households respectively. Groundnut was allocated 23 percent of total cropland while that of cowpeas was 15 percent. Other pulses and cereals like soybeans, Bambara beans, millet, sorghum and rice were also quite widely produced. In addition, more than half (52 percent) of the households produced some leafy vegetables, including *amaranths* and pumpkins (for the leaves). About 85 percent were also engaged in the production of other vegetables (mainly pepper, okra and tomatoes). However, it was noted that vegetable production was done on very

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small home gardens, of which many of the respondents could not apportion any size. Land allocation to vegetables is thus not considered in this study. From Figure 3, it is observed that maize and all legumes/pulses combined, make up over 80 percent of land allocations. This shows that the most dominant crop combination in the region is maize and at least one pulse.

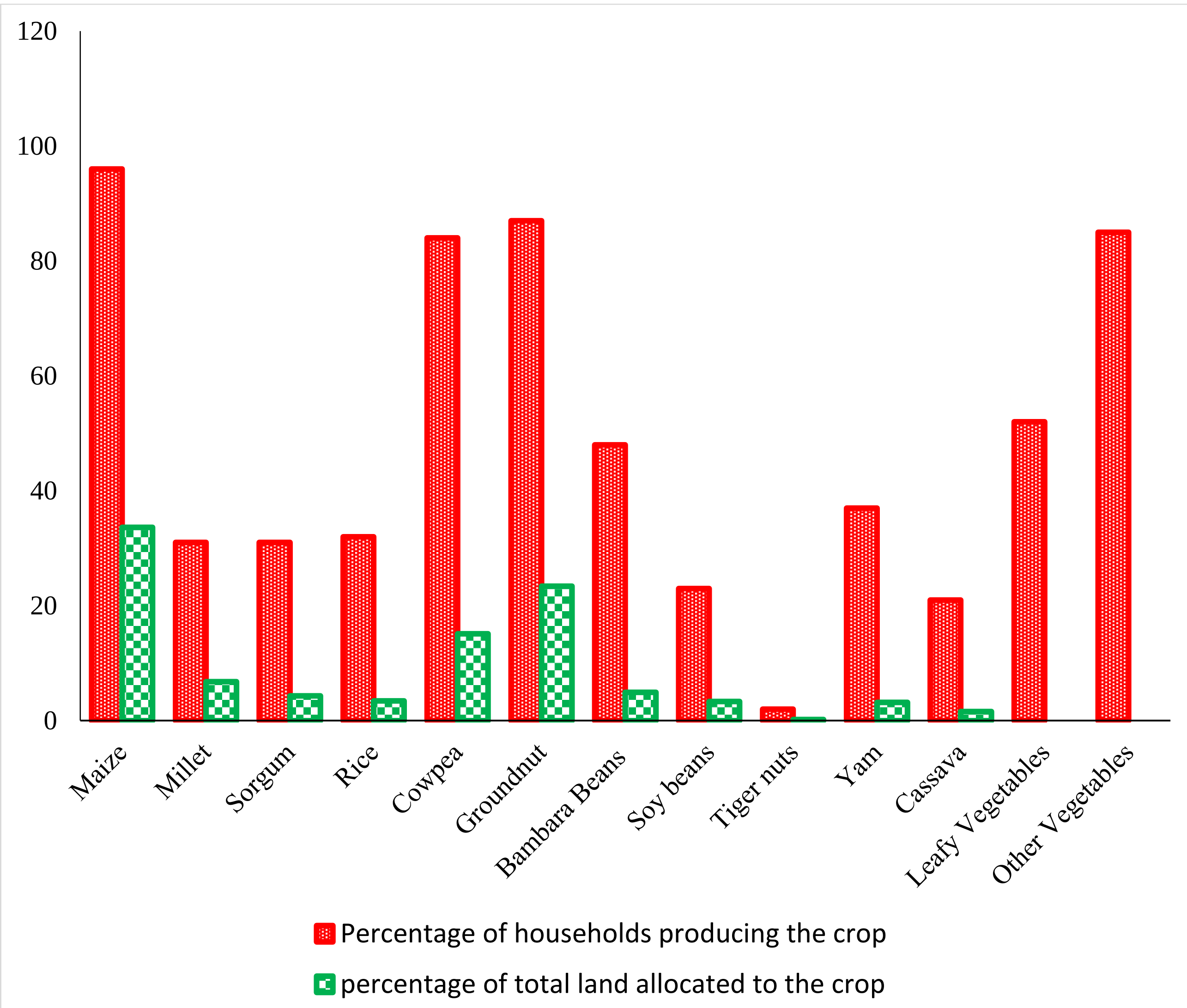

Figure 3: Crops produced by households
Source: Survey Data (2018).

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Findings from the Focus Group Discussion (FGD) and Key Informant Interview (KII) revealed that, traditionally, almost every household cultivates maize primarily for household consumption, and some pulses (mostly groundnut), for cash. Based on these patterns, much of the analysis in this study was based on the following broad crop categories: maize; groundnut; other cereals (*millet, sorghum and rice*); Other Pulses (*cowpeas, Bambara beans, soybeans and tiger nuts*); and roots/tubers (*Yams and Cassava*).

4.2.1.2 Land allocation decisions by GFSP participation

Table 6 presents a comparison of share of land allocated to each crop or crop group along the lines of participation or otherwise in the GFSP. An independent t-test was used to assess the differences in means between the two groups. This was done to get an insight into the role of government's fertilizer subsidy program in influencing household crop diversification decisions as per land allocation to the respective crops and crop groups.

Table 6: Household land allocation decisions by GFSP participation

Crop Groups	GFSP participants	GFSP non-participants	Difference
Average share of land allocated to maize	0.37	0.23	0.14***
Average share of land allocated to all other cereals	0.12	0.21	-0.09***
Average share of land allocated to groundnut	0.21	0.27	0.06**
Average Share of land allocated to all other pulses	0.23	0.23	0.00
Average share of land allocated to roots/tubers	0.048	0.049	-0.001

***Notes**: ***, **, * significance levels at 1, 5 and 10 percent respectively.*
Source : Survey Data (2018)

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The results in Table 6 show that on average, GFSP-participant households allocated more than one third (37 percent) of all household cultivated land to maize, while non-participants allocated about 23 percent. The variations in land allocation between the two groups was significant at 1 percent. On the other hand, GFSP non-particpants allocated more land to other cereals and groundnut by about 9 percent and 6 percent respectively, compared to participants. This could be due to the need to supplement their lower maize production by producing related crops for food and incomes. Land allocation to roots and tubers, and other pulses were almost equal for both groups. These results are consistent with Fearon et al. (2015), who noted an increase in the total land area under maize by 32 percent, while that of other cereals like millet and sorghume remained relatively the same after 6 years of the GFSP's implementation in Ghana. Similarly, Chibwana et al. (2012) reported that households who received maize coupons under Malawi's FSP allocated more land to maize and less to all other crops including tobacco which is the major cash crop in the country.

4.2.1.3 Crop diversification

The Herfindahl procedure was used to determine the extent of household crop diversification. The Crop Diversification Index (CDI), an index ranging between 0 to 1¸ measures the number (count) and spread (land share) of crops produced by households.

Table 7: Categorization of crop diversification among households

CDI range	Category	Percentage of households
0 to 0.49	Least Diversified	43
0.5 to 1	Highly Diversified	57
Mean CDI = 0.69		

Source: Survey Date (2018)

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As shown in Table 7, the average Crop Diversity Index (CDI) was 0.69, which is fairly high. According to Malik and Singh (2002), the closer CDI is to 1, the more diversified a household's crop production is. Households in this study were categorized into two groups based on their CDI scores as presented in Table 7. Based on this categorization, 57 percent of the respondent households were found to be in the highly diversified category, with 43 percent in the least diversified group.

4.2.1.4 Crop yield

As shown in Table 8, the overall pattern of production showed that maize was the most produced crop: consistent with the land allocation patterns. It also showed that GFSP participating households recorded higher yields across all crop groups than the non-participating households, except for groundnuts and roots/tubers. Two things are worth-noting in the production patterns. First is the massive difference in maize yield between the two groups.

Table 8: Crop yield by GFSP participation

Crops	**Yield (kg/acre)**			
	Pooled	**GFSP participants**	**GFSP non-participants**	**Difference**
Maize	474	566	230	336***
Other Cereals	219	248	170	78***
Ground nut	320	287	405	-118***
Other Pulses	174	186	143	43***
Roots/Tubers[1]	943	892	1083	191

***Note**: ***, **, * are significance levels at 1, 5 and 10 percent respectively.*

[1]value of output per acre (in GH₵) were used for roots and tubers because of the difference in units of measurement for yam (number of tubers) and cassava (kilograms).

Source: Survey Data (2018)

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Results in Table 8 show that for each acre of land allocated to maize, GFSP participants recorded over two times more output than non-participants. This difference is significant at 1 percent. A number of previous studies in SSA report positive effects of subsidized fertilizer on maize yields (Ricker-Gilbert and Jayne, 2011; Chibwana et al., 2012). This suggests the benefits derived from fertilizer use. It also reflects the skewedness of crop priority among the participating households towards maize.

It is worth noting that the GFSP participants also had a significantly higher production of other cereals than non-participants. As reported by Fearon et al. (2015), output of cereals like millet and sorghum grew by close to 70 percent despite the slow pace of increase in their land allocation after 6 years of Ghana's GFSP implementation. A similar observation was made for other pulses/legumes, of which GFSP participants had significantly higher yields than non-participants. This suggests a potential positive spillover effect of the GFSP on other crops as observed by Mason et al., (2013) in Zambia. There was no statistically significant difference between the two groups in terms of yields of roots and tubers, but non-participant households had significantly higher yields for groundnut.

4.2.1.5 Crop commercialization

The level of commercialization for respective crops and crop groups was computed using the Household Commercialization Index (HCI). This is computed as the percentage of crop output sold out of total harvest.

$$HCI_i = \frac{Quantity\ sold\ of\ crop_i}{Quantity\ \ harvested\ of\ crop_i} * 100 \quad \ldots\ldots (18)$$

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Table 9 presents results of the level of crop commercialization. The results indicate that every household sold a certain percentage of crop output for cash returns. Consistent with information from the FGDs, groundnut stands out as the most commercialized crop, with an average of 59 percent of all groundnut output being sold. Households who did not participate in the GFSP sold an average 63 percent of their groundnut output, while participating households sold 57 percent. This difference was significant at 10 percent level.

Table 9: Crop commercialization by GFSP participation

Crop enterprises	Percentage of crop output sold			
	Pooled	GFSP participants	GFSP non-participants	Difference
Maize	30	38	7	31***
Other Cereals	25	28	19	9*
Ground nut	59	57	63	-6*
Other Pulses	34	41	17	24***
Roots/Tubers	30	30	29	1
Total (all crops)	46	50	38	12***

Note: ****, **, * significance levels at 1, 5 and 10 percent respectively.*
Source: Survey Data (2018)

In the pooled results, legumes/pulses other than groundnut were the second most commercialized crop group with 34 percent of output being sold. Participants of the GFSP sold about 41 percent of all other pulses as against 17 percent for non-participants. The lower commercialization of non-participating households here could be because they allocated more land to less-commercial pulses like Bambara beans, and this also underscores their relatively high subsistence orientation. There were extreme differences in the level of commercialization for maize between the two groups. GFSP participants sold close to 40 percent of maize harvested as compared to only 7 percent by non-participants, and the difference was significant at 1 percent. The level of commercialization for all other cereals (rice, millet, sorghum) and roots and tubers was at 25 percent and 30 percent

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respectively in the pooled results. GFSP participants sold 9 percent more of other cereals than non-participants, with the difference being statistically significant at 10 percent. There was no statistically significant difference in their levels of commercialization for roots/tubers.

Generally, the results indicate that GFSP participating households were more commercialized than their non-participating counterparts, and this could be probably due to their relatively higher levels of output. Also, it is important to note that the non-participating households were less commercialized towards crops with high subsistence value especially cereal crops including maize.

4.2.1.6 Gross margins

A gross margin analysis was done to value and compare the gains from all crop enterprises using reported average market prices per unit of each crop, and accounting for variable costs. The variable costs considered include expenses on fertilizer, tractor, labour, chemicals and other inputs that households responded to have used in the production of crops. Gross margins per acre of land cultivated are discussed here, and the results are presented in Table 10.

Table 10: Gross margins by GFSP participation

Crop Enterprises	Gross margins per acre (in Ghana Cedis - GH₵)			
	Pooled	**GFSP participants**	**GFSP non-participants**	**Difference**
Maize	416	448	226	222***
Other cereals	281	323	211	112***
Ground nut	540	473	715	-242***
Other legumes/pulses	414	439	350	89***
Roots/tubers	540	502	641	139
Total (all Crops)	438	462	384	78**

Note*: ***, **, * significance levels at 1, 5 and 10 percent respectively.*
1 USD was equivalent to Ghana Cedis (GH₵) 4.7 at the time of the survey
Source: Survey Data (2018)

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The results show that roots/tubers and groundnut had the highest gross margins per acre. An average gross margin of about GH₵ 540 was generated for each acre of groundnut cultivated, with GFSP non-participants having about 34 percent higher margins. Gross margins for roots/tubers was also GH₵ 540, but there was no statistically significant difference between the two groups.

Maize and other pulses recorded gross margins per acre of GH₵ 416 and GH₵ 414 respectively. It was however observed that GFSP participant households had about GH₵ 89 higher gross margins for legumes/pulses than non-participants. For maize, GFSP participant-households recorded about two times higher average gross margins than non-participants. This could be promising for the GFSP because one of the program's main objectives is to boost yields and increase smallholder profitability (Houssou et al., 2017). This result also coincides with that of Chapoto and Ragasa (2013) who found that fertilizer use among Ghanaian maize farmers is profitable at both market and subsidized prices.

The least competitive crop group as shown by their gross margin was cereals other than maize. An average gross margin of GH₵ 281 was generated from each acre of land allocated to cereals other than maize. There were, however, large disparities between the two groups. Participants of the GFSP had about 35 percent higher gross margin from crops in this category. This may be due the potential positive spillover effects of the subsidy program discussed earlier.

4.2.1.7 Incomes

Table 11 shows means of different household incomes. Income from maize sales was separated from other crops in this analysis because it is the crop with the bias of the GFSP, as well as the base enterprise from which diversification is viewed. From the results in Table 11, total household income was about GH₵ 5, 320, of which income from crop sales dominated and GFSP participant households had a higher average. More specifically, the results show that GFSP participants (GH₵ 1567) had over four times more income from maize sales than non-participants (GH₵ 355), and this difference was significant at 1 percent. This is not surprising considering the support received from the program and the fact that participant households allocated more land to maize; had a higher maize output; and sold a far larger percentage of maize output than non-participants. Similarly, GFSP participant households had a significantly higher income from sales of other crops than non-participants. These patterns could be due to the generally higher market orientation of the participation group.

Table 11: Household incomes by GFSP participation

Income items	**Average incomes (in Ghana Cedis – GH₵)**			
	Pooled	**GFSP participants**	**GFSP non-participants**	**Difference**
Maize income	1110	1567	355	1212***
Other crops income	1474	1760	806	954***
Livestock income	726	775	613	162
Non-farm income	2010	1950	2150	-200
Total household income	5320	6051	3611	2440***

Note: ****, **, * significance levels at 1, 5 and 10 percent respectively.*
1 USD$ was equivalent to Ghana Cedis (GH₵) 4.7 at the time of the survey
Source: Survey Data (2018)

Another income item of interest is income from livestock sales. For this, the difference observed between the two groups was not statistically significant. Likewise, differences in average non-farm income between the two groups was not statistically significant.

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4.2.2 Household food consumption

4.2.2.1 Food Consumption Score (FCS)

Table 12 presents the results of households, classified according to food consumption groups based on Food Consumption Score (FCS) computation and categorization as recommended by WFP's FCS guidance sheet (WFP, 2008). For this, data on food consumption of the 247 households were collected. The data captured the diversity and frequency of consumption of different food groups over a recall period of 7 days. The approach used in calculating the FCS is discussed in section 3.3.2 of the Methodology chapter.

The results indicate that less than 1 percent of households had poor food consumption. About 44 percent had borderline consumption, while 55 percent had acceptable consumption. It was observed that only one household was in the poor food consumption group. Therefore, subsequent analysis of food consumption (by groups) was restricted to the borderline and acceptable groups.

The households in the borderline food consumption group had their diets dominated by a combination of starchy staples (cereals and tubers) and vegetables, which were consumed almost all the seven days under recall. Sugar was consumed at least six days a week with fats/oils coming along two days in the week. Pulses were consumed once in a week while consumption of fruits, meat/fish/eggs and milk was almost zero. This result implies that the quality of diet in this group was relatively poor, with a limited consumption of protein and other micronutrient-rich foods like eggs, meat and fruits.

For households in the acceptable consumption category, together with starchy staples and vegetables, which were consumed all 7 days, pulses consumption was appreciably high (3 days). Their diets also had some meat/fish/eggs and milk coming along twice and once respectively in the week under recall. Sugar (6 days) and fats/oils (3 days) were also well consumed

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Table 12: Food consumption groups by frequency and diversity in consumption

Food Consumption Groups	**Percentage of households (%)**	**Frequency Of consumption (Average number of days food groups were consumed – 7 day recall)**							
		Cereals & Tubers	Pulses	Vegetables	Fruits	Meat/ Fish/ Eggs	Milk	Sugar	Oils
Poor **Food Consumption**	0.4	4.0	1.0	6.9	0.0	0.0	0.0	2.0	0.0
Borderline **Food Consumption**	44.3	6.9	1.3	6.9	0.1	0.3	0.1	6.2	2.3
Acceptable **Food Consumption**	55.3	6.9	2.8	6.9	0.3	2.3	1.0	5.9	3.6
Pooled	100.0	6.8	2.1	6.8	0.2	1.4	0.6	6.01	3.1

Source: Survey Data (2018)

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However, just like the Borderline group, fruit consumption was very low and almost close to zero. These findings suggest that even among the acceptable food consumption group, consumption of foods rich in micronutrients is still relatively low.

There are two important observations in these results. First is the almost zero percentage of households in the Poor consumption group. Although this is striking, it is quite a true representation of food consumption patterns in the region. Similar results were found by the Comprehensive Food Security and Vulnerability Analysis of Northern Ghana (Hjelm and Dasori, 2012), which reported that only 1 percent of households in the Upper West region were in the poor food consumption group. Rural households in the Upper West region have a largely homogenous meal, composed of a maize meal (*tuo zaafi or sao*), accompanied with okra or leafy vegetable sauce. Per the computation of the FCS, a daily consumption of this "base" meal alone puts almost all households in a borderline category. Indeed findings of the FGD revealed that this meal (*sao accompanied by some vegetable sauce)* is consumed by almost all households at least 6 days in a week. Consumption of pulses, meat/fish, milk and fruits is what appeared to differentiate better-off households. Similarly, the okra/leaf sauce accompaniment, together with pepper and onions which are present in almost every Ghanaian meal, explains the very high frequency of consumption of vegetables across almost all households.

4.2.2.2 Food sources

Figure 4 presents a chart showing various sources of food for households. The results indicate that sources of food among agricultural households differ for different food groups. However, the most dominant source, especially for staple foods, was own-production. Cereals and tubers; pulses and legumes; and vegetables are the food groups mostly consumed out of own production. Milk and

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fish, though rarely consumed, are mostly purchased. Fruits recorded a very low consumption frequency but the main source was purchases. The results show a balance between purchases (49 percent) and own production (51 percent) for meat and eggs.

Notably, apart from own production and purchases, the main sources of food were gifts or wild sources. For example, the major cooking fat/oil used in the region is shea butter, which is processed from shea nuts gathered from nearby forests. Similarly, over 34 percent of households obtained fruits from wild sources. Most importantly, the FGD revealed that in the dry season, households depend on wild baobab leaves for their leafy vegetable needs. The data for this study were however collected in the rainy season, hence home-produced leafy vegetables were available.

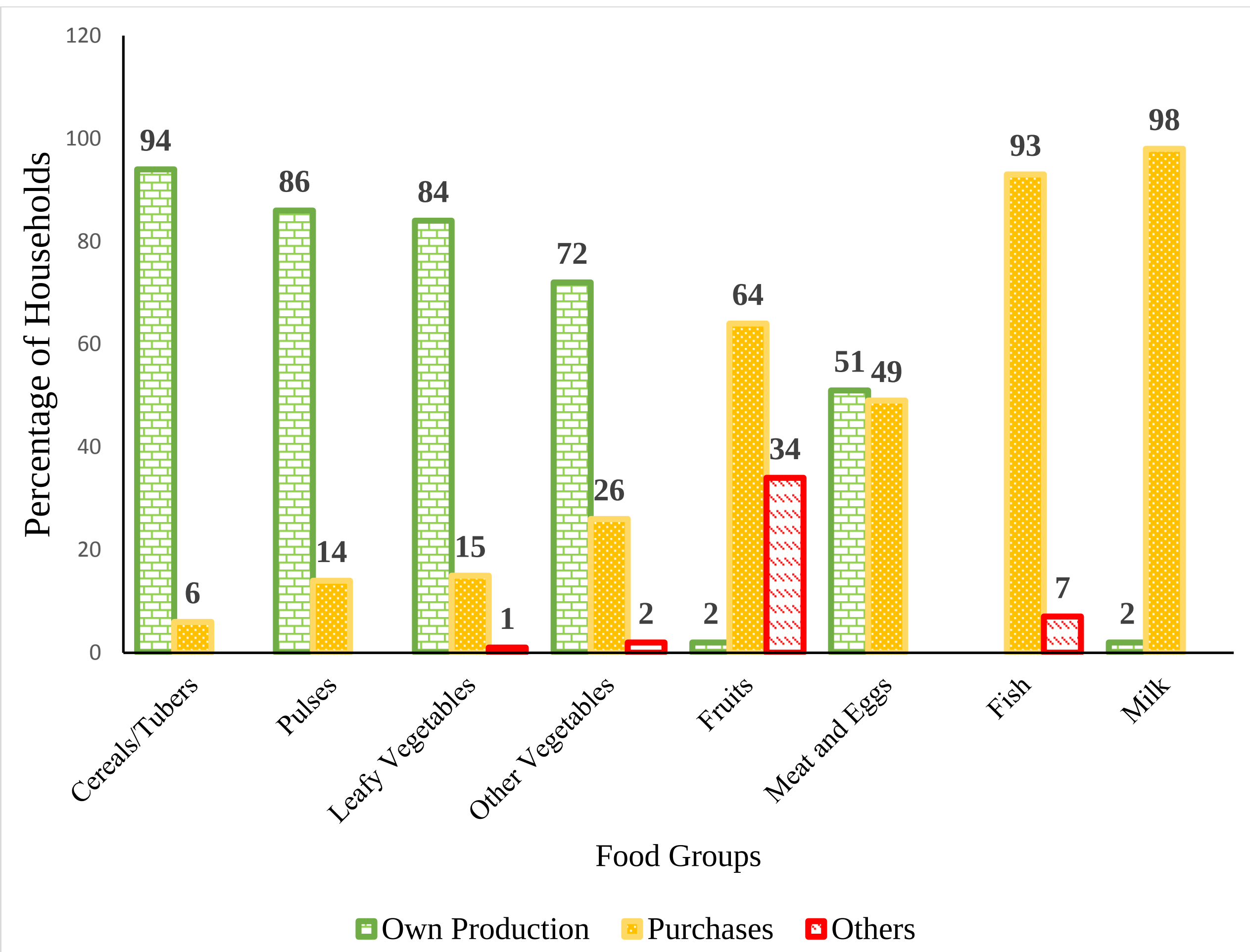

Figure 4: Main food Sources
Source: Survey Data (2018)

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4.2.2.3 Food consumption by levels of crop diversification

There are two major pathways from agriculture to food consumption at the household level. Firstly, through a subsistence pathway of consuming what is produced; and secondly, through an income pathway of food purchases by way of cash income from crop/livestock sales. For the subsistence pathway, the most promoted household production strategy is crop diversification. Results presented in Figure 5 seek to draw insights into this pathway by characterizing food consumption by crop diversification groups.

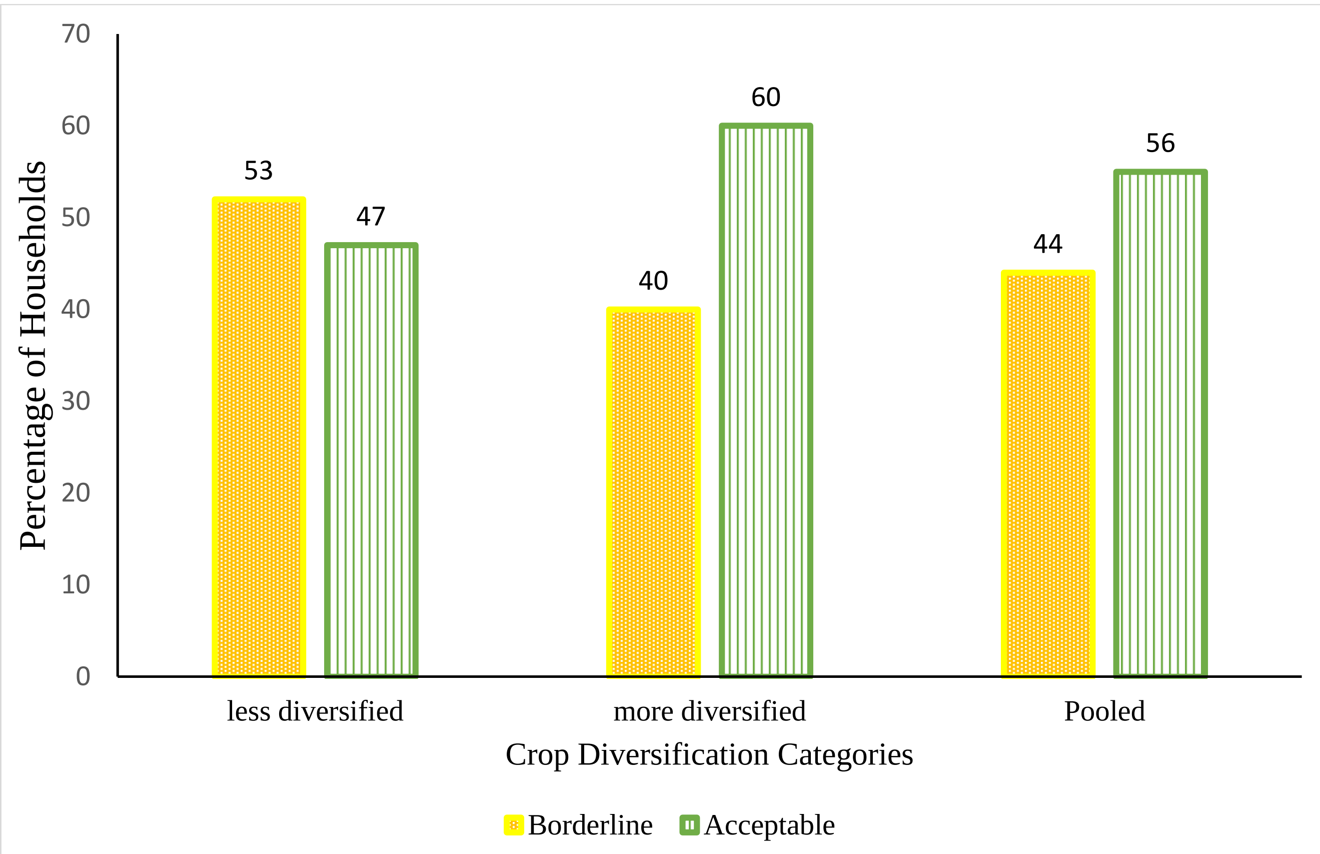

Figure 5: Food consumption by level of crop diversification
Source: Survey Data (2018)

The results reveal that a higher percentage of low crop-diversifiers (53 percent) had a borderline food consumption, compared to high crop-diversifiers (40 percent) in the borderline group. On the other hand, among the highly crop-diversified group, more households (60 percent) were in the

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Acceptable consumption category, compared to 47 percent for low crop-diversifiers. This suggests that high crop diversifiers had slightly better diets than those with low crop diversification.

Results in Table 13 below further confirm that households in the acceptable consumption group were about 5 percent more diversified in production: again underscoring the importance of crop diversification for food consumption in this region.

Table 13: Crop diversification by food consumption groups

	Acceptable consumption	Borderline consumption	Difference
Average CDI	0.72	0.67	0.05***

Source: Survey Data (2018)

To further explore the subsistence pathway, Figure 6 characterizes the differences in frequency of consumption (7 day recall) of different food groups by crop diversification groups. The results show that there was almost no difference between the two groups regarding consumption of cereals/tubers, and vegetables. This is again consistent with the general pattern of consumption in the region with regards to these two food groups. However, there were slight differences in consumption of other food groups, which in fact makes the difference in diet quality.

Generally, fruits are the most poorly-consumed food group among the households, but low crop diversifiers had a slightly higher consumption of fruits than high diversifiers. On the average, high-crop-diversified households had a higher frequency of consumption of pulses, meat/fish/eggs and milk than households with lower crop diversification.

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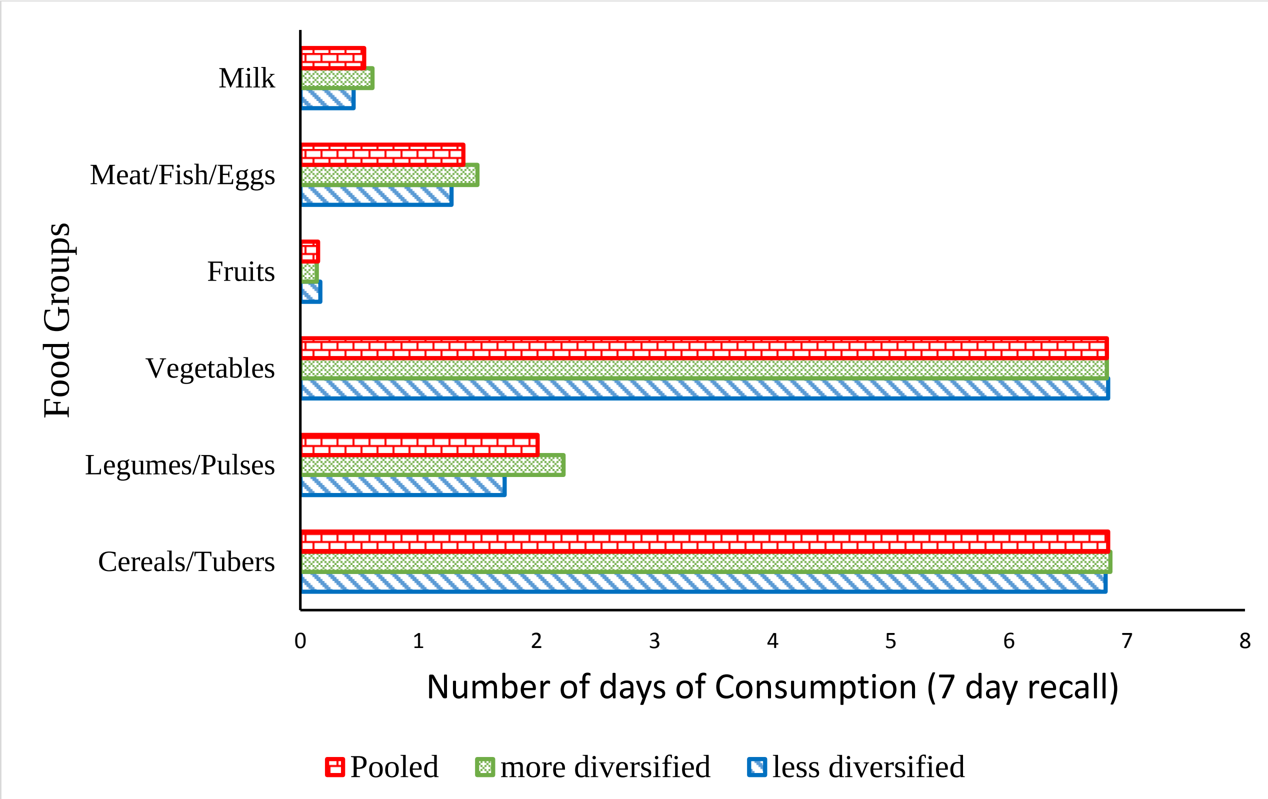

Figure 6: Frequency of Consumption of different food groups by levels of crop diversification
Source: Survey Data (2018)

4.2.2.4 Household incomes and food consumption

For more insights into consumption patterns, Table 14 characterizes food consumption groups with respect to average annual income from agriculture and other sources. This represents an exploration of the income pathway from agriculture to food consumption. The results demonstrate that there was no significant difference between the acceptable consumption group and their borderline counterparts in terms of annual total household income, but there were observable differences in the disaggregated incomes.

Average income from all crop enterprises for the borderline consumption group was found to be more than double that of the acceptable consumption group. Households in the acceptable consumption group had about GH₵ 1100 and GH₵ 400 less income from maize and all other crops

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respectively, in comparison with the borderline group. These differences showed statistical significance at 1 percent and 5 percent respectively. On the other hand, income from livestock sales (including milk and eggs) was about 60 percent higher in the acceptable consumption group than those in the borderline category. The last income item in Table 14 is income from non-farm activities. Acceptable consumption households recorded significantly higher non-farm incomes than the borderline group.

Table 14: Household income by food consumption groups

	Average Income (in Ghana Cedis – GH₵)		
Income items	**Acceptable consumption**	**Borderline consumption**	**Difference**
Maize income	444	1937	-1112***
Other crops income	1292	1702	-410**
Livestock income	883	530	353*
Non-farm income	2485	1420	1064**
Total HH income	5103	5589	-485

Note: ****, **, * are significance levels at 1, 5 and 10 percent respectively.*
1 USD was equivalent to Ghana Cedis (GH₵) 4.7 at the time of the survey
Source: Survey Data (2018)

Observations from these results show that although there is no significant difference in mean total household income between the two groups, income sources of the acceptable consumption group were more diversified. Just about 34 percent of the acceptable consumption group's income came from crop production, as against about 70 percent for the borderline group. Considering that there is a single crop season in the region, over-reliance on crop income for all household expenses could be risky.

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Also, most non-farm income activities in the region, including microbusinesses; hunting and gathering activities; and non-farm casual jobs, are mostly all-year round, and assure a more frequent flow of income. A frequent flow of income could contribute more to smoothening food consumption. Furthermore, higher crop income among the borderline group reflects their higher levels of crop commercialization. This implies that much of the households' crop output ends up in the market, rather than in the kitchen. In such a situation, diet quality is compromised if income gains do not go into food consumption, particularly of other food groups. One or a combination of these could explain why quality of diet is better among the Acceptable group, even with relatively lower incomes from farming.

4.2.2.5 Food consumption by GFSP participation

Table 15 presents a comparison of diet quality between GFSP participants and non-participants. As shown by the average food consumption score in the table, non-participant households had slightly better diets as compared to the participants. This difference was statistically significant at 5 percent. The results show that the GFSP non-participant households consumed more pulses and meat/fish/poultry/eggs than the participants. There was no statistically significant difference in consumption of all other food groups except fats/oils, for which the participant group had a slightly higher consumption. The results further show that 15 percent more non-participant households had acceptable diets compared to participants.

Results in this table suggest that non-participant households have better food consumption than participants. This could be due to their relatively higher levels of production diversification as earlier shown by land allocation decisions. These connections are explored in detail in the econometric analysis in the next section.

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Table 15: Food consumption by GFSP participation

Food Consumption	Means/percentages		
	GFSP Participants	**GFSP non-Participants**	**Difference**
Number of days consumed – 7 day recall			
Cereals/tubers	6.9	6.8	0.1
Pulses	1.8	2.4	-0.6***
Vegetables	6.8	6.8	0.0
Fruits	0.1	0.1	0.0
Meat/fish/poultry/eggs	1.2	1.7	-0.5**
Milk and milk products	0.6	0.5	0.1
sugar	3.1	2.7	0.4
Fats/oils	6.1	5.7	0.5*
Overall average Food Consumption Score (FCS)	38.40	41.00	-2.60*
Consumption groups: (*% acceptable*)	51.0	66.0	-15.00**
(*% borderline*)	49.00	34.00	15.00**

Note*: ***, **, * are significance levels at 1, 5 and 10 percent respectively*

Source: Survey Data (2018)

From the discussion above, it is observed that there are differences in production outcomes such as crop yield, level of commercialization, gross margins and income from sales between the two groups, with GFSP participants having significantly higher values for almost all of production outcomes. Similarly, there were differences in the consumption outcomes between the two groups with non-participant households recording slightly better diets than their participating counterparts. *These results lead to a rejection of the null hypothesis that there are no differences in production and consumption outcomes between participant households of the GFSP and their non-participant counterparts.*

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4.3 Objectives 2 and 3: Effects of GFSP on crop diversification and income, and their implications for household diet quality

According to the theoretical basis of the agricultural household model, farm households' food consumption depends on among other things, their agricultural production outcomes. But production is an outcome of a household decision which is also dependent on other factors and needed to be modelled first. In this study, production was modelled to be a function of, *inter alia*, participation or otherwise in the GFSP. This gave rise to a potential self-selection bias. Solving this, households' decision to participate in the GFSP had to be modelled. The entire process is summarized as follows: households first decide whether to participate or not in the GFSP (*stage one*). Conditional on the first stage decision, they make production decisions and achieve some production outcomes (*stage two*). Finally, based on the production outcomes achieved in stage two, households choose a level of consumption (*stage three*). The study therefore employed a three-step estimation procedure to analyze these interactions. But the main equations of interest are the *second stage equation* representing the production outcomes of interest and the *third stage equation* representing food consumption. Estimation results discussed in this section are therefore restricted to these two equations. Results of the first stage equation (*factors influencing participation in the GFSP*) were to get estimates of production outcomes corrected for selection bias, and are presented separately in appendix 1. It is worth noting that the two production outcomes of interest: **crop diversification** and **farm incomes** are respective proxies for the "**subsistence**" and "**income-food-purchases**" pathways from household agriculture to food consumption.

4.3.1 Effects of the GFSP on crop diversification and farm income

Table 16 presents results of the outcome equation of the Endogenous Treatment Regression for the effect of GFSP and other factors on crop diversification measured by CDI (in column two)

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and farm income measured by the value of total crop output (in column three) respectively. Here, the two production/pathway variables (crop diversification and farm income) were used alternately as dependent variables. The fact that the CDI is bounded between zero and one was accounted for in the second stage of the endogenous treatment model. This was done by issuing lower (0) and upper (1) limits to the second step equation. Also, following Dillon et al. (2015), log versions of these variables were used in order to homogenize their units of measurement to make their pathway effects in the final stage comparable. Their effects are therefore interpreted as percentage changes.

There was evidence of selection bias in both the diversification and the income models as shown by the coefficient of the inverse Mills ratio (*coefficients of lambda in the models*). The coefficient of lambda was significant at 5 percent in both models. This confirms that the decision to participate in the GFSP and the production outcomes are interrelated and modelling them as separate processes would yield misleading results. The *Wald chi-square* values for the two models were 188.87 and 360.82 respectively; and both were significant at 1 percent, indicating that all explanatory variables included in the model jointly explained crop diversification and incomes.

Consistent with the hypothesis of the study, the results in Table 16 provide a strong evidence that there exists a significant negative relationship between crop-specific input subsidy programs and diversification in production. Households' participation in the fertilizer subsidy program was associated with a decrease in the level of crop diversification by 11 percent. This result tends to support the theoretical argument that crop-specific input subsidies encourage over-dependence on a single or a few crops. Input subsidies in Malawi in the 1990s were criticized for creating and promoting over-concentration on maize (Harrigan, 2008). Similarly, Ellis (1992) reported a shift towards crops that were supported by the subsidized fertilizer despite favorable market demand patterns of the substituted crops in some cases. In more recent studies, similar patterns have been reported by Chibwana et al. (2012) and Holden and Lunduka (2010) who found that land

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allocations to maize and tobacco were higher among farmers who respectively received maize and tobacco support under Malawi's current input subsidy program. *This result leads to a rejection of the null hypothesis that fertilizer subsidies have no effect on crop diversification.*

Table 16: Effects of GFSP and other factors on the crop diversification and income

Variables	**Crop diversification** (CDI)	**Crop income** (Log of value of total crop output)
Constant	-0.381*** (0.125)	9.742*** (0.479)
Access to GFSP inputs (1=Yes)	-0.112** (0.0478)	0.243*** (0.224)
Distance to market (km)	0.004*** (0.002)	0. 007 (0.005)
Household with crop contract (1=Yes)	0.010 (0.027)	0.337*** (0.106)
Access to market information (1=Yes)	0.022 (0.020)	-0.008 (0.080)
Total land size (acres)	0.018*** (0.004)	0.060** (0.031)
Extension frequency (number)	0.001 (0.001)	-0.005 (0.003)
Years of farming	0.002*** (0.001)	-0.002 (0.003)
Relative household subsistence requirement	-0.067*** (0.023)	-0. 382*** (0. 367)
Regular household labor size (number)	0.001 (0.004)	0.085*** (0.016)
Female involvement in agricultural production/sales decisions (1=Yes)	0.031 (0.021)	-0.146* (0.0859)
Number of household's non-agricultural income sources	0.028*** (0.008)	-0.003 (0.032)
Model diagnostics		
Lambda	0.087** (0.031)	-0.294** (0.136)
Prob > chi-square	0.000	0.000
Wald chi-square (12)	118.87	360.82
Number of Observations	247	247

*Notes: ***, **, *: significance levels at 1, 5 and 10 percent respectively.*
Robust standard errors in parentheses

Source : Survey Data (2018)

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On the other hand, the results show an expectedly positive and significant relationship between fertilizer subsidy and farm incomes. This is consistent with Dorward et al. (2008), who noted that fertilizer subsidies come with an improvement in farmers' liquidity, and hence have Green Revolution tendencies of boosting crop productivity and incomes. Although the effects of subsidy programs on poverty in SSA are not encouraging due to the negative effects of other confounding factors including poor targeting (Houssou et al., 2017), some previous studies have reported income gains from participation in input subsidy programs in Malawi, Zambia and Kenya independently (Dorward and Chirwa, 2013; Mason and Tembo, 2014; Mason et al., 2015). *This finding validates a rejection of the null hypothesis that fertilizer subsidies have no effect on farm incomes.*

The findings of the effects of crop-specific fertilizer subsidies on crop diversification and incomes have implications for many aspects of livelihoods. Although there are significant income gains from the program, its negative influence on crop diversification means that much of the income comes from a single crop source, which is the subsidy-biased crop (maize). Crop diversification may contribute to improvements and diversification in crop income and, more importantly, hedge households against crop-specific risks such as pest and disease attacks, crop failure and price fluctuations. Particularly, as hypothesized in the next section, for a subsistence-oriented setting such as the one under study, lower diversification in production could imply lower nutritional diversity in local food availability. However, the massive income gains from near specialization may prove beneficial to food consumption through market purchases.

The results further show that other institutional and socioeconomic factors also contribute significantly to crop diversification and incomes. Land size significantly influenced both crop diversification and incomes positively. An additional acre of land owned by a household increased crop diversification by about 2 percent and increased farm income by 6 percent. A plausible

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explanation is that bigger land endowments provide households with opportunities for expanding agricultural production in general and the range of crop enterprises in particular. Large land sizes are usually associated with adoption of a variety of improved technologies; use of much quality inputs; and access to good support services which contribute to boosting both crop diversification and incomes (Birthal et al., 2006). Similarly, other studies have reported that land allows farmers to overcome some challenges associated with access to capital and inputs, hence improving yields and incomes (Mandal and Bzbaruah, 2013; Olwande, 2015). *This finding validates rejection of the null hypothesis that land size does not affect crop diversification and incomes.*

As anticipated, the results show that the relative subsistence requirement of households is negatively associated with both crop diversification and income. A percentage increase in a household's subsistence requirement leads to about 7 percent reduction in the level of crop diversification and 38 percent reduction in farm incomes. Households with higher subsistence requirements relative to their land possessions are more likely to allocate a bigger share of land to staples and crops with more subsistence value to meet their household basic food needs. This concurs with findings by Chibwana et al. (2012) among maize farmers in Malawi. *This result leads to rejection of the null hypothesis that subsistence requirement does not influence crop diversification and incomes*

Furthermore, the results indicate that distance from home to the nearest market was significant and positively associated with crop diversification, but had no effect on farm income. The effect of market proximity on crop diversification is consistent with the study's expectation. An additional kilometer away from a market is associated with about 1 percent increase in the level of diversification. This implies that households farther away from markets have higher levels of diversification than those closer to markets. This could be due the fact that households farther from markets depend more on own production for consumption, and hence diversification is key to their

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diets. In related works, easy access to road and market infrastructure has been found to be associated with near-specialization and high commercialization (Hlongwane et al., 2014). This result is consistent with those found by Koppmair et al. (2017) and Ibrahim (2009) who observed that households who stay farther from markets were more diversified, mainly for subsistence purposes, because market participation is costly and difficult for them. *The null hypothesis that distance to market has no influence on crop diversification decisions is thus rejected based on this result.*

An additional year of farming was associated with about 1 percent increase in the level of diversification. It, however, had no effect on income. This could be because older farmers see farming as way of life and are usually more subsistence-oriented than young farmers who are more likely to be specialized in market-oriented crops for commercial purposes (FAO, 2012). Older farmers are likely to diversify for subsistence purposes. *This justifies a rejection of the null hypothesis that farming experience does not influence the level of diversification.*

The results also indicate that an increase in non-farm sources of income by one activity increased crop diversification by about 3 percent, but had no effect on farm income. *The null hypothesis that non-farm activities have no effect on crop diversification is therefore rejected.* Households which have more non-farm income sources may be less reliant on household agriculture for basic staples. They can therefore afford to allocate their land to a range of other crops. Also, income from other sources could be used to acquire inputs and technologies that support farm diversification (Alwang and Siegel, 1999). This result is consistent with Chibwana et al. (2012) who found that Malawian farmers who had more off-farm activities allocated less land to the predominant maize and tobacco systems.

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Households' engagement in any contract for crop sales was found to be significant and positive in influencing farm income but not diversification in production. Having a contract increased income by about 33 percent. This could be due to the availability of a ready market, as well as the probability of "contract households" being generally more market-oriented, hence producing crops with higher market value. This result corroborates Wainaina et al. (2012) who found higher incomes among poultry farmers under contracts in Kenya, and also *validates a rejection of the null hypothesis that farm income is not influenced by contracts.*

Consistent with expectations of the study, the number of household members available for regular farm work was found to be positive and significant in influencing farm income. It, however, had no effect on crop diversification. An increase in labor availability by one person increased farm income by almost 9 percent. This is plausible because labor is a core input in agricultural production and its availability is expected to increase farm activity, output and incomes (Feder, 1985). *This leads to a rejection of the null hypothesis that household labour availability does not affect farm incomes.*

The results also show that households where women are involved in agricultural decision-making had about 1 percent lower incomes, but had no effect on crop diversification. This is not surprising because women are generally considered to be more subsistence-oriented compared to men. They are therefore more likely to produce crops with higher subsistence value than those with market value if they are actively involved in agricultural decision-making. (Lastarria-Cornhiel, 1997; Githinji et al., 2014; De Brauw, 2015). *The null hypothesis that female involvement in agricultural decision-making does not affect farm income is therefore rejected.*

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4.3.2 The implications of crop diversification and farm income for household diet quality

Having achieved respective levels of crop diversification and incomes from the previous stage of analysis, the final step examined the implications and relative importance of these production outcomes for household diet quality, as indicated by the Food Consumption Score (FCS). Table 17 presents an OLS estimation result of the effects of crop diversification and farm income accruing from the GFSP on household diet quality.

In this analysis, predicted values of crop diversification and farm income from the previous stage were used in alternate food consumption models as independent variables, along with other control variables hypothesized to affect diets. The control variables are the same in the alternative models. The alternation between the two production outcomes/pathway variables in the model was to provide a disaggregation between the relative effects of the subsistence pathway and income-food-purchases pathway from production to food consumption. Following Dillon et al. (2015), the dependent variable, FCS, was also log-transformed to allow for the pathway comparison between the two production outcomes.

The R-squared (R^2) value for crop diversification and income models of the consumption equation were 0.58 and 0.52 respectively, indicating that the variables included in the model explained at least 52 percent of the variation in the household food consumption. The F-static values in both models were also significant at 1 percent, indicating that all explanatory variables included in the models jointly explained quality of food consumption among households.

According to the results shown in Table 17, crop diversification is significant and positively influences household diet quality. A percentage increase in the level of diversification in crop production was associated with about 10 percent increase in quality of household diets. This could be explained by the generally high subsistence nature of agricultural households in the region. The Ghana Living Standards Survey (GSS, 2014) reported that rural households in Northern Ghana are

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over five times more reliant on own production for food, relative to the national average. Production diversification is therefore very necessary for diversification in consumption. This result is consistent with *a priori* expectation of the study and concurs with many previous findings (Jones et al., 2014; Sibhatu et al., 2015; Snapp and Fisher, 2015; Hirvonen and Hoddinott, 2017). *The null hypothesis that crop diversification does not influence diet quality is thus rejected.*

Table 17: Implications of crop diversification and income for household diet quality

Variables	**Log of Food Consumption Score (FCS)**	
	Crop diversity model	Crop income model
Constant	3.585*** (0.181)	3.259*** (0.247)
Crop diversification (*CDI*)	**0.103** (0.076)**	
Crop income (*log of value of total crop output*)		**0.005 (0.026)**
Distance to market (km)	0.004* (0.002)	0. .005* (0.002)
Female involvement in agricultural production/sales decisions (1=yes)	0.116*** (0.035)	0.150*** (0.037)
Log of non-farm income	0.027* (0.013)	0. 036*** (0.014)
Household has access to electricity (1=Yes)	-0.024 (0.035)	-0.011 (0.035)
Years of formal education of household head	0.010*** (0.004)	0.009** (0.004)
Age of household head (years)	0.001 (0.001)	0.002 (0.001)
Total household size	0.005 (0.003)	0.003 (0.003)
Agriculture as main economic activity (1=Yes)	-0.225*** (0.083)	-0.211** (0.084)
Model diagnostics		
R-squared	0.58	0.52
F-statistic	10.39***	8.99***

*Notes: ***, **, * significance levels at 1, 5 and 10 percent respectively.*
Standard Errors in parentheses

Source : Survey Data (2018)

On the other hand, farm income from the GFSP, measured by the value of crop output, was not significant in influencing diet quality. This implies that no significant increase in diet quality can be attributed to gains in income from the GFSP. Relative to the effect of crop diversification, these results suggest that the income pathway from the fertilizer subsidy program to food consumption

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is currently not effective in influencing the quality of diets of farm households in the Upper West region. A study by de Jager et al., (2017) in rural areas of Kenya and Northern Ghana found the impact of a legume grain agricultural intervention on dietary diversity to occur only through the subsistence pathway by way of diversified farming systems, but not through income gains. In Nigeria, Dillon et al. (2015) found that both the subsistence and income pathways contributed positively to dietary diversity, but the subsistence pathway was more powerful in terms of magnitude than income. A much earlier study by Immink and Alarcon (1991) found that income increases among smallholder farmers in Guatemala did not lead to any improvements in food security and nutrition situations. On the contrast, most other studies have used market access and in some cases, market participation as proxies for the income pathway and have found it to be a more relevant contributor to diet quality as compared to crop diversification (see Jones et al., 2014; Sibhatu et al., 2015; Koppmair et al., 2017; Hirvonen and Hoddinott, 2017). However, there is a general consensus among all these studies that the strength of the market or income pathway reduces in favor of crop diversification when market infrastructure is limited, and when households are very remote from urban and market centers; conditions that are dominant among the surveyed households in this study.

More contextually, plausible explanations to the relative importance of subsistence pathway could be linked with the complex interactions associated with the translation of farm income to quality consumption. Firstly, this pathway requires sufficient levels of income to translate to quality diets and nutrition (Sibhatu et al., 2015). Income growth could be beneficial to nutrition but it involves moving to relatively higher levels of income (Bhagowalia et al., 2012). Indeed poverty in the Upper West region is still widespread, despite improvement in output and farm incomes in recent years. Notably, income gains from the GFSP as observed in the previous stage of analysis is associated with specialization. In such situations, consumption out of own production becomes less important

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and the most crucial factor becomes per-capita food expenditure, which in the face of other pressing household expenses is usually in favor of basic staples (Immink and Alarcon, 1991). Secondly, the income-food-purchases pathway to quality diets and nutrition depends largely on income control within the household (Jones et al., 2014; Nyantakyi-Frimpong, 2017), and requires an availability of and proximity to well-functioning markets (Koppmair et al., 2017; Nyantakyi-Frimpong, 2017; Hirvonen and Hoddinott, 2017). These explanations are much plausible in this context considering the highly male-dominated household headship, and the poor state of market and physical infrastructure in the region. These dynamics are explored in detail by the behavior of some control variables included in the analysis.

Distance to market, a proxy for market access, was found to be significant and positively associated with diet quality. *This leads to a rejection of the null hypothesis that distance to market does not affect food consumption.* An additional kilometer away from a market improved food consumption by almost 1 percent. This implies that households who live closer to markets consumed lower quality diets. This is in contrast with the study's expectations, but it is not surprising because the previous stage of analysis revealed proximity to markets to be associated with nearly-specialized farming systems. This could be detrimental to household diets if markets are not able to provide enough diversity for consumption. Better access to markets induces farmers to engage in specialized production systems in realization of improved incomes (World Bank, 2007; Qaim, 2014). However, if the markets are not functioning enough, the income gains from specialization may not be realized for diversification in consumption (Nyantakyi-Frimpong, 2017). The results suggest that households farther away from markets have better diets from their relatively highly diversified range of output. Similar results were found by Koppmair et al. (2017) and Hirvonen and Hoddinott (2017). This finding casts questions on the ability of rural markets in the region to offer nutritional diversity. The poor market and road infrastructure could be derailing market

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integration of the region with other areas which produce food items like fruits, vegetables, poultry and dairy products, which were found to be produced on relatively subsistence levels in most households.

The study also found that household gender roles in agricultural decision making contributed positively and significantly to diet quality. This as well provides some explanations to the relative pathway effects established so far. Household diets were found to be of about 15 percent better quality when the primary woman in a household is involved in agricultural decisions. A plausible explanation to this finding is that women's involvement in agricultural decisions allows the household to enjoy the consumption and nutritional benefits associated with both output and incomes from output (Wagah et al., 2015). The FGD revealed that a common practice in the Upper West region is that after harvest, the male-head of the household allocates some number of bags of maize and other major staples to the female in charge of meals, to keep for home consumption until the next harvest. In most cases, whichever foods that accompany the staple meal throughout the year are to be provided by the woman. In such a situation, households who have women involved in agricultural decision making could enjoy decisions which involve producing a wide range of food for home consumption; how much of output is sold or reserved for own consumption; and to some extent income allocations for household benefits. This finding is consistent with results reported by Jones et al. (2014), Malapit and Quisumbing (2015) and Nyantakyi-Frimpong (2017). Women's involvement in household agricultural decisions comes with a high likelihood of them being involved in income control and allocation. Studies have shown that the person controlling agricultural income in a household may be more important to household welfare than the income itself (Kennedy and Cogil, 1987; Quisumbing et al., 1996; Meinzen-Dick et al., 2012). *This result justifies a rejection of the null hypothesis that women's involvement in agricultural decision making does not affect diet quality.*

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The results also indicate that a percentage increase in households' income received from non-farm sources increased their diet quality by almost 1 percent. *This supports a rejection of the null hypothesis that non-farm income does not influence quality of food consumption*. Off-farm activities provide households with complementary incomes to those from agricultural production and allow rural households much greater access to food (FAO, 1998). Also, off-farm activities are usually associated with a more frequent income flow, which is very important for agricultural households in a region with a single farming season. The study also found that women were more directly engaged in and had control over off-farm activities than they had over household agriculture. Activities like shea nut collection, charcoal burning and local beer (*pito*) brewing are generally dominated by women. Incomes from these activities are mostly controlled by the women themselves and could contribute positively to household welfare in general and, particularly, diet quality, as reported by Jones et al (2014).

Consistent with *a priori* expectation, an additional year of formal education increased household diet quality by about 1 percent, *validating a rejection of the null hypothesis that education has no effect on household diet quality.* This could be due to the fact that, apart from opportunities for higher incomes, highly educated household heads also know the nutritional benefits of diversified food consumption. This concurs with findings of Dillon et al. (2015) in Nigeria.

The results also indicate that households who had agriculture as their main livelihood activities consumed lower quality meals. This could be due to their over dependence on staples like maize which are commonly produced for almost all their needs. Globally, smallholder agricultural households are those with the poorest diets, and record the highest prevalence of malnutrition (Pinstrup-Andersen, 2007; Frelat et al., 2016). Biederlack and Rivers (2009) also mentioned agricultural households as one of the most food insecure and malnourished livelihood groups in Ghana.

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CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

Agriculture has been identified as an important entry point to improving the nutritional intake and status of rural households, to whom nutrition-specific interventions are often not accessible nor acceptable (Webb et al., 2012). Rural households mostly depend on agriculture for their income and food needs. However, the focus of most agricultural strategies to achieving food security and nutrition has been centered on increasing production figures, usually of staple foods. An example of such strategies in Ghana is the Ghana Fertilizer Subsidy Program (GFSP). Although globally, and in Ghana, these strategies have been successful in reducing hunger over the years, their contribution to diet quality and, by extension, nutrition is still not precisely documented. In Ghana, just as in many parts of the developing world, smallholder agricultural households are the most malnourished, despite quite some improvements in agricultural production and productivity. This could be partly due to the fact that the over-concentration of policy efforts on staples reduces diversification at the household level, leading to a decrease in the range of foods available for consumption to ensure proper diet diversity in predominantly subsistence oriented settings. On the other hand, this assertion cannot be conclusive because the expected increased productivity and production of staples could come with income gains which could be used to purchase the range of foods not produced at home. This study thus sought to make a contribution to this discussion by addressing three objectives. The first objective was to characterize the structure of production and consumption among farm households in the Upper West region of Ghana along the lines of their participation or otherwise in the GFSP. The second was to assess the influence of the GFSP and other factors on crop diversification and incomes; and finally to examine the subsequent implications of crop diversification and income for diet quality. Descriptive statistics were used to

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characterize the structure of crop production and diversification; gross margins; commercialization; incomes; and food consumption patterns along the lines of participation or otherwise in the GFSP. Insights were as well drawn into household diet quality: variety and frequency of consumption; and households' sources of different food groups. A three stage econometric approach was used to achieve the second and third objectives. In the first two stages, an endogenous treatment regression model was used to estimate the effects of the GFSP and other factors on crop diversification and income (second objective); and the third stage used an OLS regression model to estimate the implications of crop diversification and income gains achieved from the previous stage on household diet quality (third objective).

The results show that household crop production is generally well-diversified, but GFSP participants had slightly lower levels of diversification. Compared to non-participant households, they (participants) allocated more land to maize, and less to all other crops. However, they were relatively more commercialized with higher incomes from crops sales; and had higher yields, gross margins and total value of output from crop production. Non-participants of the GFSP were more diversified, with relatively lower levels of commercialization, but had slightly better diets than their participating counterparts. It was also found that every household sold some proportion of total crop output and depended somehow on market purchases for some food items; though own production was a more dominant source of food. Fish, milk, sugar and condiments were the foods mostly purchased.

Several factors were found to affect the level of crop diversification. As hypothesized, GFSP participation negatively affected crop diversification. Also, distance to market, number of off-farm activities and farming experience of household head influenced crop diversification positively, while relative subsistence requirement of the household reduced diversification. On the other hand, participation in the GFSP, household regular labour size and household contract for cop sales had

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positive influences on crop income, whereas relative subsistence requirement, farming experience and female involvement in agricultural decisions affected it negatively.

The final stage of the three-step model showed that crop diversification is a more important contributor to diet quality in the region than farm income despite its positive association with the GFSP. Other factors found to influence quality of diets included distance to market, off-farm income, education level of household head and female involvement in agricultural decision making.

5.2 Conclusions

Results of the study confirm the importance of agricultural production diversification to the diets of rural households. It also tests and confirms the growing concern that staple-biased approaches to addressing food insecurity challenges could be associated with an over-dependence on the biased crop and lead to a reduction in diversification and compromise nutritional intake. Most importantly, the study confirms that income approaches to addressing food insecurity challenges may not be fully successful if they are not backed by the necessary infrastructural support. Results show that only about 30 percent of the respondent households could access markets within a 5 kilometers radius, or had access to tarmac roads leading to the nearest market. It was also observed that proximity to market appears to encourage specialization and commercialization, but could not provide diversity to households in terms of food consumption. At the household level, male-biased gender dynamics in terms of agricultural decision making, including sales and control over incomes, further derail translating gains from agriculture to acceptable food consumption. Female involvement in agricultural decision making was highly significant in influencing household diets. More so, off-farm income appears to be a good complement to farm income and has a more

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positive contribution to diet quality. This factor is important, considering the fact that there is only one planting season in the region. Activities that support additional incomes and a more frequent flow could have a stronger smoothening effect on food consumption.

5.3 Policy recommendations

A number of policy implications arise from the results so far. Based on the findings, government and development partners alike must make efforts to support the production of a range of crop groups. Legumes and vegetable crops in particular should be given the necessary support to be produced at a level that can sustain household consumption. Vegetables are a core element of household diets, but are produced at very low scales. Legumes and pulses are feasible sources of protein and some micronutrients but support to their production is currently very low. Similarly, almost no household produced any kind of fruit for subsistence or for the market. Support to these foods could come in the form of an effective expansion of the GFSP to prop up a wider range of crops. Fertilizer and other inputs for supplementary and neglected crop groups could be given to farmers at subsidized rates, or at relatively flexible payment arrangements as it is with maize currently.

Additionally, the generally limited market and road infrastructure also proved to affect food consumption negatively, and this calls for an upgrading of rural infrastructure. The study confirmed the findings from a number of previous studies which had found that the income pathway to food consumption requires an availability of and easy access to well-functioning markets. Improved purchasing power must be supported by an availability of markets to buy from, in order for a full realization of the consumption benefits of improved income. It is thus essential to improve infrastructure to connect households to markets and other opportunities that could boost access to food.

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Findings from this study further show that households closer to markets, although more specialized and commercialized, had lower diet quality. This could imply that the markets themselves are not functional enough in terms of providing diversity to households. This challenge could be addressed by improving market integration amongst regions within the country, to produce and exchange various food groups. At the national level, this could minimize the negative effects of specialization on consumption. However, integrating rural markets is equally strongly linked to infrastructure. This again echoes the need for upgrading infrastructure. A more feasible and medium-term approach could also be the promotion of production diversification, not only for subsistence, but also for the market. Production of vegetables, fruits, livestock and some pulses is currently at humble subsistence levels despite their market potentials. Exploring these enterprises purposely for the market could provide households with alternative and additional sources of income while also providing local markets with more diversity.

Furthermore, the results suggest that households stand to enjoy the gains from agricultural interventions and household production at large when women are involved in agricultural decision making. Agricultural output and income in the hands of women are more beneficial to the entire household than they are with men. This implies that strategies should be targeted at boosting the production and income control capacity of women. This could be done by supporting women farmer groups with production and marketing opportunities. By this, they are more likely to be directly involved in some production of their own and have stronger control over the outcomes. Additionally, women could be trained and given skills to improve their off-farm income generation potentials. As was observed in the study, off-farm income more than farm income contributed to household diets. Apart from it serving as a complement to agricultural incomes and its more frequent flow, some particular off-farm activities appeared to be dominated by women, and this could mean that these are some of the income items for which they had control over, and could

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channel them to the benefit of the entire household. As such, building an environment that is supportive of general livelihood and income diversification is key. Most importantly, placing women at the heart of these efforts could be even more beneficial. Activities like shea nut collection and local beer brewing are already dominated by women. They could be trained and equipped to improve their processing and managerial skills in these activities to support household incomes and food consumption.

5.4 Contribution to knowledge

This study contributes to the existing body of knowledge on nutrition-sensitive agriculture. It confirms the role of a government agricultural policy tool in shaping two important determinants of farm households' diets: production diversity and farm income. The study confirms that, as much as the GFSP improves food production and incomes, its maize-biased nature leads to a reduction in levels of diversification in production, which actually is the most important contributor to diet quality among the target population. It also reaffirms the need for infrastructural improvement to support the income pathway to consumption. One key contribution of this study to knowledge is the disaggregation of the pathways from the GFSP to consumption. Most previous studies that have attempted to establish the effects of some agricultural interventions on food consumption have usually done so conceptualizing a direct relationship. Insights into the actual pathways of the impact of such interventions are usually lost in these approaches. This study contributes to bridging this gap by showing the effects of the GFSP first on some production outcomes before establishing their implications for diets.

Findings of the study can be used by governments, NGOs and other development partners with interest in agriculture, rural development and food and nutrition security.

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5.5 Limitations and suggestions for future research

A key finding of this study was the apparent inability of markets to offer diet and nutritional diversity to households. Although it somehow suggests that markets in the area do not function properly, the study did not advance the analysis to include that. This calls for a detailed analysis of rural markets and their ability to receive and give back a range of foods to support household diets. While addressing this, much focus could be placed on the role of market integration. This will throw light on how in-country market integration ensures food diversity in local markets and households' consumption responses and preferences. Another major constraint of this study was the lack of consideration for seasonality due to the one-time nature of data collected. As households depend hugely on agriculture for food, analysis of food consumption at different times of the year is important. For example, a good number of households mentioned the wild as their source of fruits and explained that they consume them more when they are in season. An analysis of diets using an all-year round data to incorporate seasonality will thus be helpful in gaining insights into viable strategies at different times.

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APPENDICES

Appendix 1: Treatment equation estimates for the Endogenous Treatment Model - factors influencing households' access to GFSP inputs

Variables	Coefficients	Standard Errors	Marginal Effects
Constant	0.501	0.884	
Total household size (number)	0.013	0.023	**0.003**
Age of household head (years)	0.003	0.007	**0.001**
Total land Size (acres)	0.066**	0.034	**0.016**
Sold maize in the previous season	1.180***	0.269	**0 .289**
Extension visits (number)	0.017**	0.007	**0.001**
Total Livestock Units	-0.030	0.033	**-0.008**
Awareness of the Planting for Food and Jobs (PFJ) program (1=yes)	0.571***	0.206	**0 .154**
Access to tarmac roads leading to market (1=Yes)	-1.080***	0.339	**-0.273**
Group Membership (1=yes)	-0.022	0.210	**-0.001**

Notes: Number of observations (n) =247, Wald Chi-square (3) = 61.48
Prob> Chi-square = 0.000, Pseudo R^2 = 0.29
*Significant level: *** p<0.01, ** p<0.05, * p<0.1*

Appendix 2: Variance Inflation Factors (Endogenous Treatment Model)

Variable (X_j)	VIF	Tolerance = 1/VIF
GFSP_participation	1.22	0.82
No_HHincome_Sources	2.01	0.49
Extension_Frequency	1.55	0.64
Female_Involved	1.53	0.65
TotalLandSize	1.52	0.65
Yrs_Farm	1.47	0.67
Rel_HHsubs_Req	1.44	0.69
MktDistance_km	1.39	0.72
HHReg_lab	1.28	0.78

`

CropContract	1.13	0.88
Mkt_Info	1.05	0.95
Mean VIF	**1.42**	

Appendix 3: Variance Inflation Factors (OLS Models)

Variable (X_j)	Crop diversification model		Crop income model	
	VIF	**Tolerance = 1/VIF**	**VIF**	**Tolerance=1/VIF**
CDI_Hat	1.28	0.78		
logTotalValue_Hat			1.59	0.62
MktDistance_km	1.39	0.71	1.36	0.73
Female_Involved	1.29	0.77	1.38	0.72
logNonFarm_Inc	1.23	0.81	1.17	0.85
Age	1.21	0.82	1.16	0.86
Electricity	1.15	0.86	1.11	0.90
Educ_Years	1.12	0.89	1.1	0.91
Total_HHsize	1.11	0.90	1.12	0.89
Ag_Main	1.05	0.94	1.06	0.94
Mean VIF	**1.21**		**1.23**	

Appendix 4: Household Survey Questionnaire (July-August 2018)

SECTION A: GENERAL INFORMATION

1	Enumerator's Name:	2	Date (DD-MM-YYYY): / /
3	Respondent's Name:	4	Respondent's contact:
5	District: **1.Nadowli 2.Jirapa 3.Wa East**	6	Community/Village
7	How long (in years) have you stayed in this village/community:		
8	Is agriculture your principal (number one) occupation		No = 1, Yes =2

SECTION B: THE GHANA FERTILIZER SUBSIDY PROGRAM (GFSP)

B1	**Are you aware of government's fertilizer subsidy programs?** 1 = Yes 2 = No.	**B1a. If Yes, Which of them do you know about?** 1=the coupon type, 2=PFJ, 3=Both

`

B2.	**Do you participate in any of them?** Yes = 1, No = 2 *(if NO, **kindly respond to B2a** and skip to section C)*	**B2a. If NO in B2, why don't you participate in any?** 1=the prices are still high, 2=difficulties in enrolling, 3=Low quality, 4=I am not interested 5=Others(specify):
B2b	**If Yes in B2, Which of them do you participate in currently?** 1=the coupon type, 2=PFJ, 3=Both	
B2c	**Which of them did you participate in <u>last year (2017)</u>?** 1=the coupon type, 2=PFJ, 3=Both	
B3	If **Yes in B2**, how long (in years) have you been participating in any government fertilizer subsidy program? *(since 2008 to date):*	
B4	How would you rate the price of the subsidized inputs	Still very high =1, High=2, Moderate=3, Low =4
B5	What is the distance (in walking minutes) from your home to the nearest retail store?................................	

Please complete the table below <u>based on the **2017 planting season**</u>

B6. What are your quantities of the subsidized inputs used in the <u>2017 season?</u>

B7a. Type of input	**B7b** Per unit price (per Kg) for (GHC)	**B7c** Quantity received (KG)	**B7d** Quantity used (KG)	**B7e** Which crop enterprises were the respective subsidized fertilizer applied on? (*please list all that apply* in the appropriate space)
NPK fertilizer				
SO_3NH_4 fertilizer				

`

Maize seeds				

SECTION C: FARM ENTERPRISE

Ci) ***Crops***

1) What type of crops do you grow? Please fill the tables below based on the 2017 planting season

Ci 10	**Ci11**	**Ci12**	**Ci13**	**Ci14**	**Ci15**	**Ci16**	
Plot I.D	**Crop Enterprises**	**size of plot (acres)**	**Mode of acquisition** of **this plot (land)** (Own) Inherited = 1 (Own) Bought = 2 Rented= 3 Borrowed=4 Permission from chief=4 Shared cropping=5 Family land=6 Other (specify)=7 …………………………….	**Quantity harvested** (crop yield) (Kg) *(yams in number of tubers)*	**DID you sell any?** 1=Yes 0= No	**Who usually makes following decisions on this enterprise?** 1=Male 2=Female 3=Both)	
						The decision to produce this crop	The quantity of output sold

2) Home Gardening

Ci20 **Were you engaged in any home gardening in the last year (2017)?** *(please tick)* 1=Yes 0=No	**Ci21** **If Yes in C20,** Please indicate all crops you cultivated on your home garden in the last year (**2017)**	**Ci23** **Who controls the production and harvest/sales decisions**? Male=1, Female=2, Both=3	**Ci24** **Did you sell any of the output in the last one year?** 1=Yes, 0=No	**Ci25** **If yes in Ci24**, what was the average income from sales in the 2017 season? (*Please provide a rough estimate*)

Marketing/Sales of Crop output (excluding home gardens)

`

3) Please complete the table below on marketing of crop output based the 2017 farming season

Ci30	Ci31	Ci32	Ci33	Ci34	Ci35	Ci36	Ci37	Ci38	Ci310
Crop enterprise (*as mentioned in the previous section)*	**Quantity sold** (KG) *(yams in number of sacks)*	**Where was the product <u>MAINLY</u> sold?** Farm gate =1 Market=2 Middlemen =3 Institutions (schools, hospital, etc.)=4 other =5 (specify in appropriate space)	**Price per Unit** (GHC)	**Do you have a contract with the buyer of this channel** 1=Yes 0=No	**Do you engage in any value addition on this crop?** 1=Yes0=No	**If Yes in Ci35,** What is the average expenses you incur on value addition**?**	**Transport costs (to the market)** *(provide an estimate if you use your own means)* (GHC)	**Average expenses on market fees (ticket) in the 2017 season** **(GHC)**	**Other expense made in selling this product**. *(please specify the MAIN one)* ………..

Variable inputs for crops

***4*) Please complete the table below on input used on crop enterprises based on the 2017 farming season**

Ci40	Ci41	Ci42	Ci43	Ci44	Ci45	Ci46

`

Input	**Crops applied to**	**Type** *(check input column for codes)*	**Mode of acquisition** 1 = purchased 2 = own saved 3 = farmer to farmer exchange 4 = contract 5 = credit	**Quantity used** *(Kg, liters or units where applicable: number of acres for tractor, and man-days for labor)*	**Price per unit if purchased or bought on credit** (GHC)	**Please rank the major constraints you face accessing this input** Poor availability=1, High prices=2, Lack of credit to buy=3, Other (specify)
Seed Local=0, foreign=1, hybrid=2						
Other planting materials Cuttings=0, tubers=1, suckers=2, others(specify)=3 ………………………						
Fertilizer *(non subsidized)* NPK=1 Amonia =2 Urea = 3						
Farmyard manure						

`

Machines hired(mainly tractor)						
(measured in number of acres cleared in the quantity column)						
Hired Labor Types: land clearing=1						
Tillage=2						
Sowing=3						
Chemical spraying=4 Weeding=5 Harvesting=6						
Weedicide						
Pesticides						

Cii) Animal production

1) What kind of livestock/poultry/other animal enterprises does your household engage in?

Cii10	**Cii11**	**Cii12**	**Cii13**	**Cii14**	**Cii15**	**Cii16**

`

Main livestock/poultry raised. Cattle=1 Goats=2, Sheep=3, Pigs=4 Fowls=6 Guinea fowls=7 Ducks=8 Turkey=9 Other poultry=10 (Specify) …………………….	**Number owned currently**	**Main purpose/reason for engaging in this enterprise** Food=1, Sale=2, Both=3, Cultural use e.g. dowry payment=4, Store of wealth=5, Manure=6,	**Expenses on animal feed in the last one year*)*** (GHC)	**Expenses on veterinary care in the last one year** (GHC)	**Expenses on Hired labor** (GHC)	**Other Major Production Expenses in the last one year** (GHC) **(***Please specify the main one)* ………………. ………………
Other animal enterprises e.g. Grasscutter, rabbit, fish, snail, etc.						

`

Cii) Marketing/sales of animal and animal products

2) Please complete the table below based on your sales of animals and animal products (mainly milk and eggs)

Cii20	**Cii21**	**Cii22**	**Cii23**	**Cii24**	**Cii25**	**Cii26**
Main livestock/poultry raised. Cattle=1 Goats=2, Sheep=3, Pigs=4 Fowls=6 Guinea fowls=7 Ducks=8 Turkey=9 Other poultry=10 (Specify) …………………….	**Did you sell any in the last one year?** 1=Yes, 0=No	**If yes, how many units did you sell?**	**Price per unit sold** **(GHC)**	**Where did you make the most sales?** 1 = farm gate, 2 = market, 3 = middlemen, 4 = institutions (schools, hospitals, etc.), 5 = other (Specify) ………………………..	**Transport Cost** **(provide rough estimate if you used own means)** **(GHC)**	**Other major expenses made in selling this output** **(GHC)**
Eggs		***(in units)***	***(per unit)***			

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Milk		***(in liters)***	***(per liter)***			
Other animal enterprises e.g. Grasscutter, rabbit, fish, snail, etc.						

Ciii) Other income-generating activities

1) Please complete the following table on other household income-generating activities aside agriculture

Ciii10	**Ciii11**	**Ciii12**	**Ciii13**	**Ciii14**
Activity	**Did anyone in the household engage in any of these activities?** *(in the last 12 months)* 1=Yes, 2=No	**If yes, how frequently did you receive cash income from these sources?** 1=Daily 2=Weekly 3=Monthly 4=Randomly 5=others(specify)	**How many months did you/ have you been engaged in this activity?** **(***in the last 12 months))*	**Average amount earned** *(in the last 12 months)*
Casual work (*on other people's farms*)				
Casual work (*non-farm*)				

`

Hunting/gathering: e.g. hunting, fishing, Shea nut, dawadawa, shea butter				
Salaried job				
Rent out land/ housing/sharecropping (*please record cash value of share crop or rent)*				
Remittances (transfers from friends and relatives outside the household**)**				
Pension				
Micro-business/self-employment, trading, Pito brewing, charcoal burning, hairdressing, barbering, others……………..				
Government Social Transfers like LEAP, etc				

SECTION D: INSTITUTIONAL SUPPORT SERVICES

Di. Market and community support

1	What is the nearest **Major** food market center to your community?	
2	What is the distance (in walking minutes) to this market	
3	What is your **MAIN** mode of transport to the market	1=bicycle, 2=Motorbike, 3=hired truck, 4=public transport, 5=back/head load
4	What is the nature of the road from your town to this market centre?	1=Tarred, 2=Untarred
5	What is the average transport fare (in GHC) to this market centre?	
6	What is the distance (in walking minutes) from your home to the nearest health facility? *(CHPS compound, clinic, hospital)*	
7	What is your main source of drinking water in this household?	Rain=1, 2=pipe borne, 3=borehole, 4=rivers/lakes/streams, 5=dug well, 6=sachet water, 7=others (specify)…………………………….
8	Is there electricity in this community?	

`

9	Which information and communication devices do you use frequently (*select all that apply*)?	**1**=Radio, **2**=Television, **3**=Mobile phone, **4**=Computer, **5**=Others (specify) ……………
10	Does any member of this household own any of the following transport devices? (*select all that apply*)	1=Car/Pick Up, 2=Motorcycle/Tricycle, 3=Bicycle, 4=other (specify)………………………….

Dii. Farm Support

1	What is your **MAIN** source of water for agriculture purposes?	1= Rain 2= irrigation 3 = streams/rivers 4= others (specify)
2	Do you have access to any irrigation facility in the dry season?	No=1, Yes=2
3	What is the **MAIN** land preparation technique you use on your farm	1= Manual, 2= bullock 3= tractor

Diii. Social capital

1	Are you a member of any development group/FBO	1= Yes 0= No
2	If **YES** in q1 above**,** what type of group is it?	Susu/credit group=1, Farmer coops/input supply=2, Producer and marketing groups=3, Youth group=4, Women group=5, other (specify)………………………….
3	What is the most important group function **(ONE)**	1=produce marketing, 2=input access, 3=savings and credit, 4=farmer trainings, 5=transport services, other (specify)………………………….

Div. Extension services/Access to information

1) Did you access any agricultural and/or market information from the following sources in the past one year?

Div10	***Div11***	***Div12***	***Div13***	***Div14***	***Div15***	***Div16***	***Div17***
Source	**Did you receive extension service from this source**	**Frequency in the last one year** ***(number of times in a month)***	**What kind of information did you receive from this source**: 1=Pests and diseases, 2=Markets & prices, 3=Government initiatives,	**Did this information come on time** 1= Yes, 0=No	**Did you use this information?** 1=Yes 0=No	**Was this information helpful/ relevant in your agricultural activities**	**Did you receive any information on the nutritional benefits of food from**

`

	1=Yes 0=No		4= Good agricultural practices 5=Weather 6=Storage			1=Yes 0=No	**this source**?
Extension officer (government)							
Researchers							
Farmer to farmer							
Farm Demonstrations							
Print media: newspapers, magazines							
TV/radio							
NGO							
Others (specify)							
Did you receive any information on the nutritional benefits of food from any of the sources above? 1= Yes, 0=No							
If Yes, which source? 1=Extension officer, 2=Researchers, 3=TV/Radio, 4= Print media, 5=NGO							

Dv) Credit services

1). Have you **applied (asked) for credit (loan)** from the sources indicated below over the last three years? No=0, Yes=1. If **YES**, please fill in these details. ***Please fill ONLY the first two columns if you did not get the loan.***

Dv11	**Dv12**	**Dv13**	**Dv14**	**Dv15**	**Dv16**	**Dv17**	**Dv18**	**Dv19**	**Dv110**
Source of Credit	**Did you get it?** 1=Yes0=No	**If No,** why did you not get it (***Main*** *reason*) 1=high default rate 2=lacked guarantors	**If YES in Q2, what proportion of the credit applied for did**	**If YES how was it received** 1= as a group	**Main reason for going for the credit** 1=farm inputs 2=school fees 3=food	**Did you use ALL of this credit for the inten**	**If No to Dv17, how else did you use this credit:** 1=farm inputs 2=school fees	**Have you started repaying this loan?**	**If YES What proportion have you**

`

		3=didn't adhere to all requirements 4=lacked collateral 5=couldn't access lender 6=Other(spe cify	**you get:** 1=1/4, 2=1/2, 3=3/4, 4=all	2=Indiv idual	4=land 5=livestoc k 6=offset a problem I had 7=Farm equipment 8=non - farm business/tr ade 9=buy livestock 10=other, specify… ………… ……	**ded purpo se:** 1= Yes 0=No	3=food, 4=land 5=livestock 6=offset a problem I had 7=Farm equipment 8=non -farm business/tra de 9=buy livestock 10=other, specify…… …………… …….	1=Y es 0=N o	**repa id:** 1=1/ 4, 2=1/ 2, 3=3/ 4, 4=al l
Farmer group/co operativ e									
Merry go Round									
Money Lender									
Bank									
relative/f riend									
NGO									
Other (specify) ……… …..									

SECTION E: HOUSEHOLD SOCIO-DEMOGRAPHY

i) Please complete the following table about yourself and your household

`

<table>
<tr><td>Gender of HHH
1 = Male
2 = Female</td><td>Age of HH
(years)</td><td rowspan="2">Marital status of HH
1 = single
2 = Married
3 = divorced
4 = separated
5 = widowed</td><td rowspan="2">Level of Education of HHH
1 = No schooling
2= primary,
3=MSL/JHS
4= SHS
5=Technical/Vocational
6=Training College/Polytechnic/diploma
7= University and above</td><td>Number of years of farming:</td></tr>
<tr><td colspan="2">Religion:
1=Muslim,
2=Christian,
3=Traditionalist</td><td>Ethnicity (please write):</td></tr>
<tr><td colspan="3">No. of children (0 – 17 years):
No. of adults (18 to 63 years):
No. of adults (above 64 years):</td><td colspan="2">What number of your household members are available for farm work regularly:</td></tr>
</table>

SECTION F: HOUSEHOLD FOOD SOURCES AND CONSUMPTION

NB: *The person to be interviewed in this section is the one who is involved in preparing meals in the household*

Respondent's Name: ………………………………………………………….

Relationship with the Household Head: 1=Wife, 2=Daughter, 3=mother, Other (specify)…………………..

Fi). Dietary Diversity

Seven Day Food consumption Recall

a) Did **you or anyone** in your household eat anything (meal or snack) **OUTSIDE** the home yesterday? No=0, Yes=1

b) If **Yes to Q.a above,** who was it**? (*Select all that apply*): s**elf=1, spouse=2, child (young) =3, child (adult) = 4, others (specify)………………………………………..

1) Now, I would like to ask you about all the different foods that your household members have eaten in the **last 7 days**.

`

Kindly tell me **how many days** in the past week your household has eaten the following foods? [*For each food, ask what the primary source was as well as the second main (secondary) source, if any*].

Broad Food Groups	Types of food	Did **you yourself** consume this food yesterday? (*anytime from morning to evening*) **1 = Yes, 0= No**	Was this food consumed in the household **yesterday**? (*anytime from morning to evening*) **1 = Yes, 0= No**	**In the last 7 days**, **how many days** has the household consumed these food items?	**Source of Food** **1**=Own production, **2** = Purchased **3** = Food aid **4**=Borrowed/ credited **5=**Exchange/ bartered, **6** = Payment in kind for work, **7** = Received as gift, **8** = Others (specify in the applicable space)	
					Primary (Main source)	**Secondary** (2nd Main source)
Cereals	Maize and food prepared from maize					
	Millet and food prepared from millet					
	Sorghum and food prepared from sorghum					
	Rice and food prepared from rice					
	Wheat and food prepared from wheat, bread					
	Other starchy grains (specify)…………………					
Roots and Tubers	Yams,					
	Cassava					
	Potatoes					
	Other starchy roots/tubers (specify)					
Legumes	Beans, cowpeas, Soybeans, all other beans and peas					

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Nuts and seeds	Groundnuts, any nuts, cashews, seeds like pumpkins (agushie) or sunflower, sesame					
Dark Green Leafy Vegetables	All green leafy vegetables, leaves such as beans leaves, pumpkin leaves, potato leaves, kontomire, cassava leaves, moringa, amaranths, others…………………… …………………………………………					
Other vegetables	cabbage, carrot, green pepper, cucumba tomatoes, onions, garden eggs, okro, pepper, others *(specify all*					
Fruits	Mango, Pawpaw, Orange, Water melon, Pineapple, Banana, Avocado (pear), others *(specify all)*……………………………………………… …………					
Red meat and Poultry	Beef, pork, sheep, goat, chicken, guinea fowl, duck, grass-cutter, other bush meats, others (specify all)..					
	Fresh, smoked or dried Fish or Shellfish, crabs, lobsters, etc.					
Eggs	Any Eggs					
Organs	Liver, kidney, heart					
Milk and milk products	Milk, fresh milk, fermented milk, fresh yoghurt, cheese, other milk foods and products ……………………..					
Palm oil	Palm oil, Palm soup, or any meal from palm fruit					
Oils & fats	Vegetable oil, shea butter, margarine, other fats / oil					
Sweets	Sugar, honey, jam, cakes, candy, cookies, pastries, cakes and other sweet (sugary drinks)					
Condiment	Any other foods, such as condiments, coffee, tea?					

F ii). Household Food Insecurity Access Scale (HFIAS)

	HFIAS Question	Response **1=Yes, 0=No**	If **yes**, how often **in the past 4 weeks?** **1**= 1-2 times **2**= 3-10 times **3**= over 10 times

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1	Did you worry that your household would not have enough food?		
2	Were you or any household member not able **to eat the kinds of food you preferred** due to lack of resources?		
3	Did you or any household member have to eat **a limited variety** of foods due to lack of means to buy them?		
4	Did you or any household member have to eat some foods that you really did not want to eat because of lack of resources to obtain other types of food?		
5	Did you or any household member have to eat **a smaller meal** than you felt you needed because there was not enough food?		
6	Did you or any other household member have to eat **fewer meals** in a day because there was not enough food?		
7	Was there **ever a day when there was no food** to eat of **any kind** in your household because of lack of resources to get food?		
8	Did you or any other household member have to **sleep at night hungry** because there was not enough food?		
9	Did you or any other household member go **the whole day and night without eating anything** because there was not enough food?		

1) Kindly complete the table below regarding food security situation in your household, **in the last <u>four</u> weeks**.

Fii) General issues on household food consumption

1	Who makes decisions on income allocation in the household	Male=1, Female=2, 3= Both
2	Who decides what food is prepared in the house	1-Male, 2-Female, 3-Both
3	Who decides what food items to be purchased	1-Male, 2-Female, 3-Both
4	Does your cultural, religious or personal beliefs prohibit the consumption of some specific foods	No=1, Yes=2
5	If yes to Q3, what kinds of foods are they? Kindly indicate the major two:	a. b.
6	If **yes to Q3,** what do the beliefs say:	
7	Do you believe the response to Q5 yourself?	No=0, Yes=1

THANK YOU!!