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DEPARTMENT OF FOOD ECONOMICS

PERENNIAL CROP PRODUCTION: IMPLICATIONS ON WELFARE OF FARMERS IN NORTHERN GHANA

MOHAMMED AMIN KHAMA

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MOHAMMED AMIN KHAMA

(MPHIL AGRICULTURAL ECONOMICS)

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THESIS SUBMITTED TO THE DEPARTMENT OF FOOD ECONOMICS, FACULTY OF AGRICULTURE, FOOD AND CONSUMER SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY (MPhil) DEGREE IN AGRICULTURAL ECONOMICS

JUNE, 2020

DECLARATION

I, Mohammed Amin Khama, hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this University or elsewhere:

Signature:……..…………………… Date:…..…………………………

We hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University for Development Studies.

Supervisor: GIDEON DANSO-ABBEAM (PHD)

Signature:……..…………………… Date:…..…………………………

Head of Department: BENJAMIN TETTEH ANANG (PHD)

Signature:……..…………………… Date:…..…………………………

ABSTRACT

Crop production in Northern Ghana over the past decades has been mostly annual crops. This, however, has been characterized by low productivity as a result of degraded soil conditions, reliance on unpredictable rainfall pattern, and also, in most cases, lack of access to the right primary inputs and market incentives. All these contribute to making farmers worse-off. Thus, increasing poverty levels and food insecurity. One way of addressing this increase in poverty levels and food insecurity is by considering tree crops. As a result, this study seeks to assess whether tree/fruit crop production as an alternative approach to crop production in the Northern Ghana contributes significantly to farmers' welfare. The study administered a semi-structured questionnaire to 384 farm households selected through a multi-stage random sampling technique (simple random, purposive sampling and cluster sampling methods) from six (6) districts in Northern Ghana. This study identifies the determinants of perennial crop production by employing the bivariate probit model, and also, to test the complementarity and/or substitutability of cashew and mango production in Northern Ghana. Results of the bivariate probit estimation show that cashew and mango are substitutes. Factors such as access to credit, the distance of farm from home and distance of farm from the market has a positive and significant bearing on cashew production. On the contrary, household size, FBO membership and years spent in school are likely to affect the production of cashew negatively. With the determining factors for mango production, household size, access to extension services and FBO membership have positive and significant effects on mango production, contrary to the age of respondent which has a negative and significant influence on mango production. Using Propensity Score Matching to correct for self-selection bias and observed endogeneity, the study found out that producers of perennial crops have higher consumption expenditure per capita and higher income levels (a proxy for welfare) than annual crop producers. Finally, the effect of perennial crop production on livelihood diversification and food security was assessed within the framework of Conditional Mixed Process (CMP). The study also revealed through the CMP analysis that perennial crops contributes significantly to food security through livelihood diversification in the Northern region. It was also observed that the proportion of income earned from the production of perennial crops significantly contributes to livelihood diversification. The study, therefore, recommends that more educational campaigns and sensitization on perennial crop production needs to be done to create awareness and, subsequently make farmers to adopt the perennial crop production (Mango and cashew) as an alternative means of livelihood. Moreover, programs and policies should be designed towards strengthening the facilitation of FBOs and encouraging the youth to go into the production of perennials for an enhanced welfare. Also, access to credit and extension services should be intensified to enable perennial crop farmers increase their output, and subsequently improve their welfare.

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DEDICATION

I dedicate this academic output to my grandparents, Mohammed Haruna Khama and Fatima Nabala Khama.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

ATT	Average Treatment Effect for the treated
CAADP	Comprehensive African Agricultural Development Program
CDP	Cashew Development Project
CIA	Conditional Independence Assumption
CMP	Conditional Mixed Process
ECOWAP	ECOWAS Agricultural Policy
EDAIF	Export Trade, Agricultural and Industrial Development Fund
GCDP	Ghana Cashew Development Project
GEPA	Ghana Export Promotion Authority
GEXIM	Ghana Export-Import Bank
GIZ	German Development Program
HDDS	Household Dietary Diversity Score
ITFC	Integrated Tamale Fruit Company
LDI	Livelihood Diversification index
MDG	Millennium Development Goals
NDA	Northern Development Authority
NEPAD	New Partnership for Africa's Development
PERDP	Planting for Exports and Rural Development Program
PSM	Propensity score Matching
SDGs	Sustainable Development Goals
UNDP	United Nations Development Program
USAID	United States Agency for International Development
WFP	World Food Program

CHAPTER ONE

Introduction

Agriculture remains the pillar of most developing economies in the World in that it provides livelihood support for 40% of the global population and serves as the biggest source of income and job creation for the rural poor (DeeHan, 2015; FAO, 2014). Agricultural production has a range of interconnected facets in every society of the world as it openly relays to food security, environment, farm income, government expenditure or subsidies, among others (Ogazi, 2010). There is also a growing global awareness on the security of food and environmental problems associated with the crop production chain. As a result, most nations are being confronted with the challenge of drawing policies to re-articulate agriculture towards safer and more sustainable practices (Robidoux, 2018). The United Nation's agenda on Sustainable Development Goal (III) which advocates for "zero hunger", observed that there is the need for a reflective shift in global food and agricultural system if we are to cater for sufficient nutritional needs of the 815 million people who are hungry today and the additional 2 billion people expected to be undernourished by 2050 (Foresight, 2011; UN, 2015) Therefore, to help eliminate the incidence of hunger by ensuring an increase in agricultural productivity and sustainable food production systems, significant investments in agriculture cannot be underestimated (UN, 2015).

The sustainable production system in agriculture has always depended on the flexibility, efficiency and several functions of perennial trees and forages which are cultivated alongside annual legumes, cereals and oil species. But it is, however, worth noting that, research, technologies and markets have been centered only on the limited number of annual species to cater for the growing demand for food ((FAO, 2014). Is it also evident that the future challenge is how to be able to feed the projected 9 billion consumers by 2050 through increasing food production? Several concerns to address this challenge have been raised about how agriculture will adapt to climate variations, how food security can be improved, extreme poverty eliminated, have all fueled to enhance the roles perennial crops will play in future farming systems (Dixon and Garity, 2014, EY Africa 2030, 2014).

Perennial crops have received much attention in terms of research over a decade as a result of their potentials of improving ecosystems services in agricultural systems (Kane, 2016). Meanwhile, of particular reverence to global food security is the production of annual grains (DeeHan, 2015; FAO, 2014). Upon expanding the yield of primary grain crops since the middle of the 20th century, incidence of malnutrition still prevails in almost two out of every seven people globally. Significant portions of lands are subjected to annual crop production to cater for the increasing population of the globe. Moreover, production of non-food goods such as biofuels, among others is undeniably competing for land with food production (Glover, 2012). Notwithstanding the progress achieved in annual grain production, it still brings about the depletion of topsoil and its nutrients into both ground and surface water where they accumulate as pollutants. Substituting annual grain production for perennial crops has the potential of addressing most setbacks to sustainability that are seen in grain production (DeeHan, 2015).

In Africa, Perennials crop products are becoming more intensive in knowledge, inputs and quality control, partly due to rising health standards imposed by importers. Africa's substantial market share in perennial crops may indicate that the promotion of these crops could make a major contribution to Africa's growth (Fold, 2008). Large-scale production of perennial crops in Africa can be traced back to 1914 in

West Africa, with the exceptions of areas under German colony. European traders collected oil palm produce from indigenous producers and collectors. Furthermore, a significant breakthrough in the production of cocoa began in the late 19th century that saw Ghana and southern Nigeria leading producers over half a decade (Kane et al., 2016). Also, 220 million people of the world's 800 million undernourished people live in Sub-Saharan Africa (FAO, 2014). Several studies (World Bank, 2017; Economic development report in Africa, 2017, African Economic outlook, 2017; and EY, 2014) indicate the population of about one billion to double in 2040. With this, hunger is sure to rise without a significant upgrade of African soils. Some studies ((Foresight, 2011; Glover, 2012), have observed that the primary priority to boosting agricultural productivity to cater for the food needs of the rising population is to restore African soils. This calls for diverse and interrelated strategies to be able to attain sustainable and equitable food security (World Bank, 2016; Godfray, 2010). To address this issue, perennial crops can serve a vital role in ensuring sound and equitable environmental and social food systems (Rogé, 2017)

Perennials recently have been recommended as an alternative approach to transform agriculture (Glover, 2012; Rogé, 2017). Substituting annual grains with perennial relatives of similar or mixed crops could help generate environmental services, improve labour efficiency and climate resilience, reduce seed cost and also produce livestock fodder or fuel-wood (Rogé et al., 2018). Perennials also offer a wide range of services to the broader society which include; greenhouse gas mitigation and gains in water quality which can be traced to its unique soil building properties (Culmann et al., 2013). Crops once established provides living roots and soil cover that continues over a long period of time (Larkin, 2014)

1.2 Problem Statement

The United Nations Sustainable Development Goals (SDGs) advocates among other goals for Zero Hunger (Goal 1) and Sustainable Production and Consumption Systems (Goal 12), taking into consideration the need to maintain quality habitat for all species, clean water and also taking steps to limit the effects of climate change (UN, 2015). Global demand for food is increasing with increasing population vis-à-vis limited arable land which faces the risk of degradation over the years (Kuyah, 2019). Thus, the need to reconsider how the World grows, distributes and consumes food (Li, 2019). If this is well articulated, it will just be enough for agriculture, forestry and fisheries to provide sufficient food for the growing population as we generate decent incomes, without compromising social-centered rural development and environmental protection (UN, 2015).About 500 million of smallholder farms worldwide, the majority of which are dependent on rainfall, provide up to 80% of the food consumed in most parts of the developing world. Investing in smallholder farmers is the surest way to increase food security and livelihoods of the poor, as well as producing for both local and international markets (Zamfir, 2016; UN, 2015).

According to the 2010 report of the African Development Bank, as cited in EY Africa report, 2014, agriculture alone supports the livelihoods of 80% of the African population, by way of providing employment for more than 60% of its active labour force, and for about 70% of the poorest in the world. The report further observed that growth in agriculture has double effect as envisaged in poverty reduction and growth in other sectors.

Several concerns have been raised by developed nations about the threats confronting annual crops from perennial relatives (FAO, 2014). Perennial crops in agriculture are plants that can be harvested severally once planted before replanting is done. Contrary to perennial crops, annual crops can only be harvested once. Perennial crops range from fruit trees (juice and commodity crops such as mango, cashew, cocoa, coffee, orange, etc.), to perennial grasses which can be used for food and for biofuels. Such crops may also include plants used for decoration purposes like shrubs and flowers. Alternatively, it is easier to classify perennial crops as not ‘‘annual crops’’, which to a greater extent puts more weight on the variations in its lifespan as well as the number of harvests exhibited by perennial crops (Tregeagle, 2017).

Perennial crop production has both direct and indirect impact on biodiversity and ecosystems; habitat conversion, pollution, inappropriate cultivation techniques and water usage are the key direct impact. Indirect impact includes hunting, fishing and recreation as well as in-migration (World Bank, 2017). Perennial grasses could also help significantly to mitigate global climate change and energy security problems, if there can be consistent high yields (Weih, 2013). The production of perennial fruits has the potential of increasing farmers’ income and welfare together with their access to food given the favorable biophysical conditions for growing such crop (Vico, 2016) Reganold and Glover (2016) also observed that soils in most of the Sub-Saharan African countries are very much depleted to a degree that even adding fertilizer makes no significant effect on their productivity but rather further deteriorate their fertility. Therefore, growing perennials such as trees, shrubs, and legumes among others can substantially help rebuild soil quality as well as reduce pest as the crops grow and eventually increase yields.

Significant portions of arable lands over the years in the northern region of Ghana have been subjected to continual production of annual crops. This has led to varied environmental problems such as soil erosion and degradation, dry land salinity eutrophication and nutrient leaching (Bell, 2014). Re-strengthening the production of profitable perennial crops in to the agricultural landscape can help revitalize the original vegetation by way of improving upon ground cover and water usage (Vico et al., 2018).

The Ghanaian perennial crop sector over half a century has been largely dominated by cocoa and coffee production. Although other crops such as orange, oil palm, mango and other fruit crops do exist, their production over the years has been relatively on small-scale for both domestic consumption and the local market. Recently, much attention have been given to large scale production of cashew and mango due to their prospects of commanding considerable values in terms of price in both domestic and international markets, which have a direct positive impact on the lives and welfare of farmers.

Several interventions have been put forward by the Government of Ghana and international agencies to strengthen the production of perennial crops over the years. Among these interventions include; trees for food security by the World Agroforestry Center, the Cashew Development Project (CDP), production of seedlings under the tree crop policy of Ghana, with the recent one being Planting for Export and Rural Development Program (PERDP), implemented by the Ministry of Food and Agriculture (MoFA).

Majority of crops produced in the Northern region of Ghana over decades have been annual crops. This, however, have been characterized by low productivity as a result of degraded soil conditions, reliance on unpredictable rainfall pattern, and also, in most cases, lack of access to good market incentives and basic inputs (WFP and MoFA 2012, Darfour and Rosentrater, 2016). All this contributes to making farmers worst-off. Thus, increasing poverty levels and also making them food insecure. As a result, this study seeks to assess to whether an alternative approach to crop production in the Northern region by considering tree/fruit crop (cashew/mango) production as against annual crop production will contribute significantly to farmers' welfare. In recent times, governmental, non-governmental and the private sector organizations over the years have enrolled programs and projects in support of the production of mango and cashew in the northern region of Ghana. Among them include the Export Trade, Agricultural and Industrial Development Fund (EDAIF) and the Integrated Tamale Fruit Company (ITFC) programs which supported farmers in mango production, the cashew development program under the Ghana tree crop policy and other programs enrolled by GIZ, MEDA, among others. Moreover, cashew and mango have been earmarked as part of the seven selected perennial crops for the Planting for Export and Rural Development Program. These crops command huge potentials in both the local and the international domain. As such, can contribute significantly in reducing poverty and improve the welfare of farmers. Despite all the potentials they possess, limited research has been done relating to their impact on farmer's welfare and food security in Northern Ghana. The author is yet to know a study on the impact of perennial crop production on the welfare of the farm households in Ghana in general, and northern Ghana in particular. This study, therefore, seeks to assess the impact of perennial crops production on the welfare of farmers in the Northern region by focusing on two main crops: cashew and mango cultivated in the study area.

1.3 Research Questions

This study seeks to address the implications of perennial crop production on farmers' welfare by answering the following questions;

1. What drives the choice of perennial (cashew or mango) crop cultivated by farmers in the Northern Ghana?
2. What impact does the production of perennial crops have on the per capita consumption expenditure and income per capita of farmers in Northern of Ghana?
3. What is the impact of perennial crop production on household food security through livelihood diversification in the Northern Ghana?

1.4 Objectives of the Study

The overall objective of the study is to assess the impact of the perennial crop production on farmers' welfare of in the Northern region. Specific objectives are:

1. To identify factors influencing the choice of perennial (cashew/mango) crops cultivated in Northern Ghana.
2. To assess the impact of perennial crop production on welfare of farmers in Northern Ghana
3. To estimate the impact perennial crop production on livelihood diversification and household food security through livelihood diversification in Northern Ghana

1.5 Justification

Several studies on perennial crops differ in relation to the type of crop studied, socio-economic and agro-ecological conditions, and duration of crops as well as factors peculiar to a given area of study, which usually makes it difficult to generalized findings to cover entire country or regions. This calls for a country/region or area level specific studies on different types of perennial crops (Debela, 2009). Reganold and Glover (2016) in their study on "a cure to Africa's soils" recommended the need for the international community to increase its investments in the development of perennial crops as well as research in areas that are less or not even explored at all by farmers and researchers.

Perennial crops in Ghana like cashew and mango are characterized by relatively long term investment as it takes many years before trees starts flowering and fruiting. However, the production of associated crops can be identified as a strategy to cushion the skewed returns on investments in perennial tree crops to make the production of such crops a successful long term livelihood activity for rural households. A strategy that largely remains until now, unexplored (Akesse-Ransford, 2016).

This study, therefore, seeks to examine the welfare and food security implications of cultivating perennial crops (cashew and mango) as an alternative or complement to annual crops such as maize, rice, and soybean, among others. Productions of perennial crops are expected to contribute to the body of existing but limited literature especially on perennial plants and the area of the study. The study also sought to provide empirical evidence that could help in formulating policies that will fit in to the national, regional and international policies such the Economic Community of West African States Agricultural Policy and New Partnership for African Development (ECOWAP-NEPAD) and the Comprehensive Africa Agricultural Development Programme (CAADP). The study would also contribute to policies within Ghana regarding the realization of Sustainable Development Goals (SDGs), which advocates among others for ‘zero hunger’ and sustainable production and consumption systems, taking in to consideration the need to maintaining quality habitat for all species (UN, 2015). At the national and local levels, the study will provide policy recommendations for adoption into the Planting for Exports and Rural

Development Programme (PERDP) as well the Northern Development Authority (NDA).

1.6 Organization of the Study

The study is designed as follows: Chapter one gives a background of the study, problem statement, the research questions and objectives and how the study is organized. Chapter two provides relevant literature review on the study. Chapter three describes the study area and the methods of data collection and discusses the conceptual framework. The results and discussion are presented in Chapter four. Chapter five contains the conclusion, policy recommendations, limitations of the study and suggestions for future research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents related and relevant literature to the study. Overview of perennial crop production in Ghana, economic and environmental importance of perennial crop production is also discussed. The overview of cashew and the mango industry in Ghana are presented. Finally, the theoretical and empirical reviews of relevant literature relating to the objectives of the study are also discussed in this chapter.

2.1 Perennial Crop Production in Ghana

Large-scale production of perennial crops in Africa can be traced back to 1914 in West Africa, with the exceptions of areas under German colony (Ross, 2014). European traders collected oil palm produce from indigenous producers and collectors. Furthermore, a significant breakthrough in the production of cocoa began in the late 19th century that saw Ghana and Nigeria as leading producers over half a decade (Kane et al., 2016). Ghana's perennial crop sector for decades until recently has been dominated mainly by cocoa. Several attempts have however been put forward by successive governments to develop and explore the full potentials of other non-traditional perennial crops. Among them include; cashew, mango, rubber, oil palm, shea and orange. Except cocoa, cashew and mango are the two perennial tree crops that have gained attention of farmers in Ghana in the last two decades. Cashew exports from Ghana increased significantly from just about US$ 1.45 million in 2002 to US$ 91.29 million in 2012 (GEXIM, 2018). The huge spike in cashew exports in 2011 is caused by an unprecedented hike in prices for raw cashew nuts in 2010, and a return to a more moderate price level in the years after (African Cashew Alliance, 2010). Perennial crops can be distinguished by a number of important factors from traditional annual crops: “(1) the long gestation period between initial input and first output, (2) an extended period of output flowing from the initial production or investment decision, and (3) eventually a gradual deterioration (usually) of the productive capacity of the plants” (French & Matthews, 1971).

Tree crop farmers commonly view the different types of crop activities as part of an investment portfolio (Paul, 2017). Food crops provide the primary food for feeding the family. In contrast, perennials like cashew and mango give a medium to long-term investment providing the necessary capital for farm expansion and other household expenditures (Groothius, 2016). The two types of crops thus often serve as complements, rather than as substitutes, and intercropping perennial and annual crops are, therefore, a commonly observable phenomenon among smallholder farmers in Ghana.

As previously mentioned, perennial crops have a long-term potential with respect to farm income but also have some shortcomings compared to annual crops, which may impede the further expansion of tree crop cultivation in Ghana (Ntsiful, 2010). Noticeable examples are the high initial investment costs and long capacity-building of the trees (Gutierrez, 2015).

From a development perspective, the prospects and potentials for different kinds of agricultural chain transformation can be seen as most relevant for tree crops in Ghana (Wardell and Fold, 2013). The relatively huge sunk cost of plantation establishment and uncertainty in future crop yields and prices emphasized the need for a broader range of livelihood activities (Lazos- Chavero, 2016). Cultivation of associated crops (e.g. yams, rice, maize or groundnuts) can serve as an outcome as they can be smoothly and successfully intercropped with cashew and mango to guarantee the farm household of food and income (African Cashew Alliance, 2010). Moreover, it is fundamental that households make use of all the byproducts that come out of the value chains to expand their activities beyond exportation of the unprocessed raw products, to capture the maximum benefits of mango and cashew production for the Ghanaian economy (Acquaye, 2018).

The rest of this section will provide a more in-depth description of the perennial crops cashew and mango with respect to their prevalence in Ghana, their economic potential and their weaknesses, their current importance to farm livelihoods in Ghana and recent developments relating to tree crop domestication and sustainability traits.

2.2 Cashew Production

Cashew (*Anacardium Occidentale L.*) is a humid perennial nut tree that is commonly native to South America, with the centre of origin known to be Central Brazil (Johnson 1973 and Nair 2010). Cashew mostly became a major export commodity for several countries after its introduction into Asia and Africa, following the explorations of European conquerors, mainly Portuguese. About 4.7 million tons of cashews were produced across the globe in 2011, which was almost equally distributed between Africa and Asia, and also, with 1.8 million tons and over 2 million tons of cashew apples were produced in South America, namely, Brazil (Agyemang, Zhu and Tian, 2016).

The increasing attention in cashew crop is shown by the fact that cashew kernel, (the main product cashew is cropped for) is a high-value luxury commodity with progressive production volumes and sales over the last 20 years (FAO, 2013). Also, there are expectations that the market will remain robust for some time due the considerable potential to the cashew market for high economic end products, such as cashew nut shell liquid, broken nuts, and cashew shell cake (Costa, 2017). It is interesting to note that, cashew has been largely produced in developing countries where it is both an agricultural commodity that significantly contributes to gross domestic product and export earnings at the country level (Osabohien, 2019). It is also an essential source of livelihood for smallholder farmers that constitute the majority of the producers and processors worldwide (Fitzpatrick, 2011). Therefore, the cashew industry plays a significant role in the economic development of countries like Ghana, Nigeria, Ivory Coast, Vietnam, and India, and should thus, be considered a key contributor to the achievement of the United Nations Sustainable Development Goals (SDG) (Adeigbe, 2015). Indeed, the cashew industry could be positively exploited in this sense for investing in smallholder farmers with a particular focus on women, creating revenues and employment opportunities, and promoting small-to medium-scale industrialization processes, especially in rural areas (Dendena, 2014).

Cashew production has been steadily increasing over recent years, which corresponds to an increase in the cultivated area from 1,963,000 ha in 1992 to greater than 5,300,000 ha in 2011 and an increase in productivity per hectare almost doubled from 475 to 805 kg/ha in the same reference period (FAO, 2013). The limited improvement in cashew productivity can be ascribed to constraints in the development of cashew species through conventional breeding, for which there is still a limited understanding concerning vegetative propagation methods, including micro propagation (Dendena, 2014).

2.2.1 Cashew production in Ghana

Cashew (*Anacardium occidentale*) was introduced in Ghana and other West African countries by the Portuguese in the pre-colonial period, but was not actively promoted until shortly after independence in 1960, just to be abandoned quickly after again by the new regime up until the early 1990s (Armah, 2018). Cashew production in Ghana is concentrated in the western parts of Brong-Ahafo and Northern regions, near the Ivory Coast border. Cashew is drought resistant, does well under high temperatures and favors light to medium-textured soils; ecological conditions that are common to Ghana's interior and forest savannah zones (Groothius, 2016)

Cashew as a perennial crop is mostly intercropped with other crops, particularly staples, to ensure the farm household has adequate food for consumption. In Ghana, cashew farms are strongly clustered around the well-accessible towns and villages of Bole, Sawla-Tuna-Kalba, Damongo, Kintampo and Wenchi districts. In recent years, cashew production in Ghana has increased significantly due to high demand and a flourishing export market. It is estimated that about 40,000 farmers in Ghana are into cashew production (African Cashew Initiative, 2013).

The Ghana Export Promotion Authority (GEPA) noted that cashew had become the leading non-traditional export earner in the agricultural sub-sector by contributing $196.7 million to non-traditional export earnings in 2016 (GEXIM, 2018). The estimated production area currently stands at 89,000 hectors, and this has created about 40,000 and 1,800 jobs both in the production and processing chain, respectively (ibid).

The premier effort by the government of Ghana to promote the cashew industry was engineered under the six-year (2001-2007) Ghana Cashew Development Project (GCDP), which was funded by the African Development Fund to the tune of US$11.54 million (GEXIM, 2018). Preliminary studies that were undertaken by the Ministry of Food and Agriculture before the implementation of the GCDP in 1998 revealed that Ghana has a high potential of increasing the production of cashew and kernels for both domestic and export markets (Dendena, 2014). Other studies also revealed that cultivating cashew has the potential of generating additional income for the rural population, and thus contributes to reducing poverty (Feliciano, 2019).

It can, therefore, be observed that significant and positive development of the cashew industry followed the successful implementation of the GCDP. This was made known by the end of year report published in 2010 that, the total land area dedicated to cashew production had increased tremendously from 18,000 hectors in 2000 to 70,000 hectors in 2010. The reports further revealed that raw nuts production has increased from about 5,000MT in 2002 to 29,000MT in 2010 (GEXIM, 2018). This resulted in the significant growth in the export of raw cashew nuts with its corresponding positive results on rural poverty reduction, especially in the five main regions in Ghana where cashew is grown (Peprah, 2018).

Although, there are strides in the industry, the significant challenge to it is the near-collapse of the existing processing facilities as a result of the takeover of the marketing of raw nuts by foreign buyers (African Cashew Alliance, 2010). As a result, an estimated 82% of the nut is exported out of the total production output to mainly Vietnam and India without value addition. The stiff competition for raw materials by foreign buyers led to the collapse of about nine to eleven of the fourteen cashew processing factories in the country (Dendena, 2014). Table 2.1 shows the export destinations of Ghana's raw cashew nuts and their corresponding percentage import share to importing countries across the globe.

Table 2.1: A Schedule of Ghana's Cashew Export

Imports of Ghana's Cashew by Share	
Export Destination	Share (%)
India	46
Viet Nam	36
China	7
Singapore	4
United Arab Emirates	3
Brazil	2
Netherlands	1
United States	1
Total	**100**

Source: GEXIM Newsletter, 2018

Cashew is a high-value cash crop that can contribute significantly to farm household incomes. In Ghana, cashew is expected to play the role of money-spinner or the 'new cocoa' and is considered as an essential crop to broaden and diversify the current export base (Ajayi, 2012). In addition to cashew nuts which are the main product, cashew trees offer other useful byproducts that can create additional value for farm households. Notable cashew byproducts are cashew apples and cashew gum. Cashew apples are highly nutritious and can be eaten fresh or juiced. Cashew gum has many potential non-conventional and industrial uses that need to be further explored (serving as an alternative for gum Arabic is a prime example) (Gyedu-Akoto, 2011).

2.3 Mango Production in Ghana

Commercial farming of grafted mango (*Mangifera Indica)* varieties has been increasingly adopted by Ghanaian farmers since the late 1990s, mainly due to programs on food security sponsored by the United States Agency for International Development (USAID) and efforts of the Ministry of Food and Agriculture (MOFA) and other Ghanaian government and private programs (FAO, 2013). For almost a decade now, the mango sector has experienced considerable growth because of significant increase in both local and international market demand (Yaro, 2017).

Production of mango in Ghana is largely centered on three main zones, namely; the southern belt (Accra), the middle belt (Brong-Ahafo regions) and the northern belt (Micca, 2016).

Production of mango in the Northern belt over the years has been spearheaded by the Export Trade, Agricultural and Industrial Development Fund (EDAIF) and the Integrated Tamale Fruit Company (ITFC) programmes with particular attention on exporters and out-growers, respectively (Gyedu-Akoto, 2011).

Diagram 2.1 depicts the distribution of regional mango outputs and yield per ha

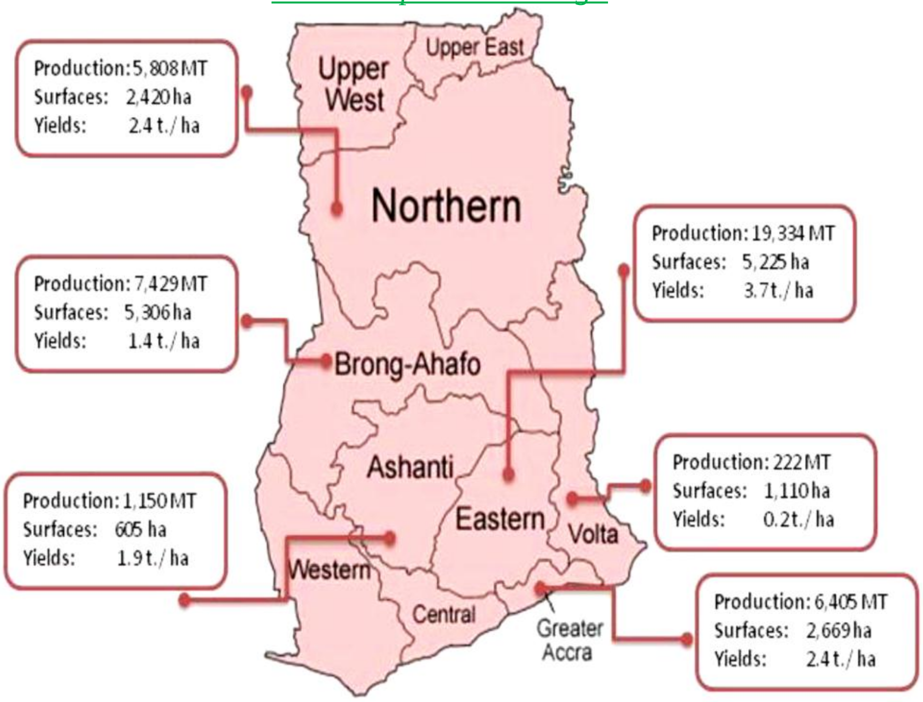


Figure 2.1 Regional Distribution of Mango Production in Ghana (2009-2010)

Source: Ghana National Mango Study, 2012

Mangoes produced in Ghana have diverse destinations. First, the local urban markets commonly traded through a network of wholesalers and retailers. Second, export markets for fresh fruit, primarily to Europe, including the fair trade and organic niche markets (Van Melle, 2013). To facilitate these exports, public and private stakeholders have commenced efforts to set up cold storage facilities at the harbor. Finally, a large share of mango is sold to processing firms. Fruit processing has developed into a competitive industry in Ghana (Adams, 2019).

The country successfully exports fresh-cut fruit (through BlueSkies Ltd.), and produces juice and pulp for domestic, regional and international markets (through Sunripe Ltd) (Zakari, 2012).

Ghana has a comparative advantage over neighboring countries because it has two harvest seasons in the south (peak and minor season). Several producer associations have emerged over the past decade, each of which federates more than 100 farmers, for whom they sell collectively, organize farm services such as pruning and spraying, and in some cases establish a pack-house (Ajayi, 2012). The mango associations in the south and out-grower schemes in the north have a strong focus on exports. In contrast, other organizations in the Brong-Ahafo region aim to improve household welfare by promoting local marketing of the fruit (Acquaye, 2018).

Ghana has no specific policy interventions towards mango alone. There is, however, more intensive intervention towards the horticultural sector. It must, however, be emphasized that the mango in recent times is receiving enormous attention from both the private and the public sectors. EDAIF's intervention, for instance, is an indication of active involvement by a governmental agency.

Table 2.2 Policy Interventions Enrolled to Strengthen the Horticultural Industry in Ghana

Project name and donor	***Description***	***Period***	***Amount (in USD)***
TIPCEE (USAID)	Increase exports of agricultural (and horticultural)	2004-2009	$30 million
HEII (World Bank)	Promote diversification and innovation in horticultural industry, strengthen its competitiveness and maintain market shares	2004-2007	$9.85 million
EMQAP (AfDB)	Increase the incomes of horticultural crop farmers and exporters incomes and of cassava producers	2007-2011	$28.5 million
GHPPP (USAID)	Link Ghanaian with distribution networks worldwide by assisting producingin meeting safety, quality and other market standards	2002-2005	
MOAP (GIZ)	Improve the competitiveness of agricultural producers, processors and traders on regional, national and international markets	2004-2011	$22.6 million
MiDA (MCC)	Increase production and productivity of high value cash and food crops in three zones of Ghana , and enhance the competitiveness of high value cash and food crops in local and international markets	2007-2013	$547 million
ADVANCE (USAID)		Replaced TIPCEE, no specific information provided	

Source: Ghana National Mango Study, 2012

2.4 Review of Theoretical Literature on Adoption

2.4.1 Concept of adoption

Adoption is defined in varied ways. In the works of Feder, Just, and Zilberman (1985), adoption is the degree or magnitude of use of a new technology. The adoption process comprises the choice of the means (land and labor) and quantity that is to be allocated to the new technology in case the technology is not divisible (mechanization, irrigation). However, in case of isolatable technology, the choice development involves area allocations and level of use (Feder et al., 1985). Thus, the adoption decision process is made of a concurrent choice of adopting or not and the intensity of use of the firsthand technology.

In the works of Rogers (1983), adoption is the practice or nonuse of a firsthand technology by a farmer at within a period of time. Rogers (1983) defined five categories of adopters: innovators, early adopters, early majority, late majority, and laggards. Innovators are usually the principal adopters of the new technology. They are: Eager to take risks, younger in age, from highest social class, having good financial situation and closest to other innovators. The financial possessions they have help them in absorbing any failures they might encounter. Early adopters are expected to be risk taker, younger, enterprising and educated. However, late adopters are risk averse, older, less educated and conservative. Early majority have highest degree of opinion leadership. Their opinion is most of times respected by other villagers. They are discriminating and judicious in making decisions about innovation. Laggards adopt but later discontinue due to dissatisfaction. The categorization of adopters is useful in case there is confirmation indicating flow from one category to the other, conditional on the technology introduced.

Also Rogers (2003) defines adoption as the decision of full use of an innovation as the greatest course of action is available. Adoption is a decision-making process, in which an individual goes through a number of psychological stages before making a final decision to adopt an innovation.

2.4.2 Theories explaining adoption of new technologies

In developing countries, three theories explain farm household production choices (Kazianga, 2013). These are: profit maximization, utility maximization and risk aversion.

2.4.2.1 Profit maximization theory of adoption

Schultz (1964) theorized farm households in developing countries as "poor but efficient". This means that poor households do the best they can under the difficult situations they find themselves. They are effective in distributing their resources and respond to price incentives. Farm households are perceived as profit maximizers in a perfectly competitive market. Bliss & Stern (1982) have empirically examined this theory and found an opposing result in India. They showed that farmers in Palandur, India were not doing the best that they could do given their resources. They concluded that farmers are not efficient and profit maximizers as Schultz (1964) suggested. They concluded that farm households making trade-offs between profit and other household goals cannot be typically categorized as profit maximizers.

2.4.2.2 Utility maximization theory of adoption

Utility maximization theory consider's farm households as both families and firms. They are both consumers and producers. In the nonexistence of labor market and unlimited land supply, Chayanov (1966) demonstrated the impact of household size and structure on farmer behavior. Chayanov (1966) showed that the amount of land cultivated be subject to the ratio of consumers to workers in the farm household. In the primary stages of the household's life cycle, a small acreage of land is cultivated due to the small age of the children. As time goes, the children grow in age, become economically active and enter the family labor force, the amount of cultivated land expands. In Chayanov's model, peasant families operate the land with the labour of family members alone. Households can accommodate more working members by renting or buying more land. They have relatively free access to land. He concluded that farm households do not always maximize production or profit by producing as much as possible but rather seek to maximize utility with a trade-off between household consumption and leisure. In the context of Ghana, Chayanov theory is very limited in the sense that household labor can be shared or hired especially for weeding and harvesting. Access to family labour can be difficult due to the growing strength of education and rural urban migration. In Ghana, 44.3% of the currently employed population work as skilled agricultural and/or fishery worker (Ghana Statistical Service, 2014c). In Ghana, 18% of land is owned by the State, 80% by traditional rulers and 2% by both (Bugri & Yeboah, 2017). Access to land depends on land tenure agreement. The co-existence of these systems of law regulating land leads to some difficulties, especially for women and the rural and urban poor. Under the customary land administration system, land access in Ghana have a tendency to favor use and ownership by men, particularly when it comes to inheritance (Kotey and Tsikata, 1998). However, under the customary land administration, a non-member of the community can access land through purchasing, renting, gifting, licensing or sharing contractual arrangements. Under the statutory land administration system, legal procedures are most of the times complex. In addition, the procedure is costly. Bearing in mind the high rate of illiteracy in rural areas, lack of money, access to land under the statutory land administration is very limited.. The model of Chayanov was criticized for its assumption of missing labor market and unlimited land supply.

According to Becker (1965), farm households maximize utility through consumption of available goods subject to full income constraint. In case where market is perfect, production and consumption decisions are considered as separable. According to I. Singh, Squire, and Strauss (1986), the main reasons of that separability are: exogenous price, independent leisure and labour-time, household labor allocation determined by market wage and income representing the only link between consumption and production of the farm households. However, in case of imperfect markets for either output or input, farm decisions are non-recursive. The reason is that the household decides on time allocation related to production, affecting then consumption of leisure (Singh et al., 1986). Profit maximization and maximization of utility theories fail to include risk and uncertainty in farm household decisions process.

2.4.2.3 The risk averse farm household

A study conceptualized farm households' risk aversion through two theories: expected utility and disaster-avoidance theories (Prajapati, 2020). From the expected utility theory perspective, a farm household chooses among risky alternatives mainly based on their preferences related to the possible outcome and the probability of occurrence of that outcome (Guentang, 2018). This theory pictures farm households as utility maximizers constrained by risks. However, from the disaster-avoidance theory, a farm household who faces risky income sources will first isolate safe alternatives and from the safe alternatives, chooses based on expected utility (Kazianga, 2013). In this case, the decision-maker wants to avoid the risk that his/her income falls below the subsistence level. Based on this criterion, a farm household could prefer risky income sources or low risk activities. This means that at low levels of income, farm households do not behave according to expected utility theory (Kaseke, 2017).

2.4 Modeling adoption theory

Numerous instruments for variations can be combined through perspectives: Leadership, innovation suitable with standards and values, and attitudes/motivation toward innovations are all stated in at least half of the theories and across organization, innovation, individual, and client perspectives (Miles, 2012). Granting that some of these theories may be y studied often for the reason of comfort of measurement, and not all of them have regular directionality of findings, these factors are openly dominant to understanding adoption (Hitt, 2017). They deliver a proposed direction for academics to focus future research on the drivers of adoption and may serve as the basis for developing interventions to promote adoption of evidence based practices (Deters, 2017). This consistency, however, is constrained by a lack of accurate definition and measurement of mechanisms that can lead to misperception for policymakers and organizations trying to adopt innovations (Goldsmith, 2015). For instance, when leadership is perceived as CEO influence or the presence of champions or opinion leaders, it has a positive effect on adoption. Other conceptualizations of leadership, such as centralized or excessively formal, top-down leadership, are not advantageous to adoption, and leadership metrics such as tenure, education, and regency of education are not related to adoption (Kaseke, 2017).

Four adoption-specific theories (Cohen and Levinthal1990; Damanpour and Schneider 2009; Gallivan 2001; Valente 1996) and one theory of adoption within the framework of implementation (Greenhalgh et al. 2004; Meyer and Goes 1988) provide either quantitative or qualitative data to support the constructs in their models.

From a practical perspective, however what most effectively illuminate next steps for practitioners, researchers, and policymakers is empirical data.

In considering how adoption-specific theories and theories that described adoption in the perspective of implementation differ, we establish that theories that described adoption in the context of implementation were more probable to include features of the innovation as central to adoption (Deters, 2017). Damanpour and Schneider (2009) simplified the key role of innovation features as most significant in whether an organization adopts the innovation, whereas Klein and Sorra (1996) recommended it is rather the suitable for the innovation with organization's values that is most imperative.

Features of innovations, however, are likely to have random salience depending on the type of innovation since well-defined interferences such as hand-washing have more concrete and observable steps of adoption associated to the implementation of challenging psychosocial interventions (Grabowski, 2014). Adoption-specific theories were also more expected to center on early markers of practicality, such as leadership, attitudes toward adoption, and organizational size and structure, whereas theories in the context of implementation were probable to address issues related to long term implementation and sustainability, such as cost-efficacy, relative advantage, and government policy and regulation (Glazerman, 2016). These findings suggest adoption should be considered a separate construct from the other steps of implementation.

As suggested above, these findings propose opportunities for clarification of innovation adoption theory. Although this combination centers on theories, examinations of included studies recommended measurement of mechanisms differ considerably and also contributed to a nonexistence of clarity. For example, the two studies that measured leadership each measured it in a different way: Gallivan (2001) piloted interviews with 53 individuals for a period of 2 years in a single organization and determined qualitatively that the nature of leadership (top-down, bureaucratic) was linked with adoption, and Valente (1996) measured opinion leaders using social network selection measures in multiple case studies. To facilitate decision-making by policymakers and organizational leaders, researchers should reconcile these specific construct-measure combinations in a way that will provide consistent measurement to increase validity and replicability of the findings here (Svensson, 2018). Similarly, measurement of the dependent variable, adoption, also was measured in different ways. Methodization through a single, widely accepted outcome measure would be suitable. Future studies should identify measures that are feasible within evaluation or research contexts and that have demonstrated validity in predicting adoption (Lopez, 2021).

Despite the fact that this review provides full information on external, organizational, staff, and innovation characteristics, perspectives from the beneficiaries of innovations (clients, patients, customers, or other stakeholders) are not well embodied and suggest research is conducted primarily from the organizational perspective, not from a consumer perspective (Deters, 2017). Only five studies included any information on these beneficiaries. Given the importance of stakeholders to service delivery (Aarons et al., 2009), and increasing importance of patient perspectives in health care (Sox, 2010), consideration of these perspectives when generalizing findings could build up the theories of adoption.

2.4.1 *Empirical studies on adoption in Sub-Saharan Africa*

Though there is some general consensus among scholars about determinants of agricultural technology adoption, the empirical results of earlier studies on off-farm income and technology nexus has been contradictory. For instance, the study by Gedikoglu and McCann (2007) showed that farmers' off-farm income significantly influences their decision to use improved technologies depending on capital and time that is required by the technology, the off-farm income can significantly be a determinant that promotes adoption or a factor that defers adoption. The outcome of the analysis using multivariate probit regression on farmers' overall farm in the U.S. income effect on farm technology adoption verifies that injecting manure into the soil, though capital-intensive practice, has significantly positive effect by off-farm work and adoption of record keeping, which is a labour-intensive practice, is negative and has a significant influence on off-farm work (Deutz, 2018). While the early adoption theories focused on profitability, subsequent studies have emphasised that farm size, risk and uncertainty, information, human capital and labour supply also affect adoption (Yussif, 2019). However, the study was carried out in the U.S and the current study provides empirical evidence of the significant bearing of off-farm income on agricultural technology adoption decisions in the African setting.

Bandiera and Rasul (2011) presented evidence on how farmers' choices to use a new crop relate to the adoption choices of their network of family and friends. They found an inverse-U shaped relationship, implying that social effects tend to have positive outcomes when the network contains few adopters and get negative with many adopters. They also established that the adoption choices of farmers who have better information about the new crop are less sensitive to the adoption choices of others. Finally, they highlighted that adoption choices are highly related within family and friends than religion-based networks, and uncorrelated among individuals of different religions. They theorized an inverted U-shaped individual adoption curve, implying that network effects are positive at low rates of adoption, but negative at high rates of adoption.

Ali *et al*. (2017) studied the contribution of social capital to promoting the adoption of soil fertility management technologies in Tororo district, Uganda in a survey using 103 female and male farmers. Using Logit regression model, they highlighted that the tendency of presently adopting legume cover crops was more with farmers with memberships to groups relative to other community members. Some social capital variables that were found to have significant effect on increasing the probability of adoption of legume cover crops include the extent of cooperation, information diffusion and linkages with external agencies. Farmers' associations performed impressively on such indicators of social capital as cooperation, extent of trust, information sharing and participation in collective activities. They therefore suggested that strengthened local organisations and intensified multipurpose cover crops could raise adoption of soil fertility management technologies. This is a relevant recommendation but there are multiple soil fertility management technologies in the study and farmers could adopt some components or the full package and hence using a logit model bears some methodological shortcomings.

Genius *et al*. (2013) examined the role of information dissemination in promoting agricultural technology use and diffusion. They considered the effect of two information channels, namely extension services and social learning. They established a theoretical model of technology adoption and diffusion, which they then empirically apply, using duration analysis, on a micro-dataset of across olive producers from Crete (Greece). Their study contended that both extension services and social learning are key factors that drive technology adoption and diffusion, although the usefulness of each typology of informational channel is supported by the existence of the other. They highlighted that informational transmission takes place not only through extension services but also between farmers themselves: a larger stock of adopters in the farmer's reference group induces faster adoption (-0.293 years), while a larger distance between adopters increases time before adoption (0.172 years). The effect of social learning can be compared to the effect of information provision by extension personnel (mean marginal effects on adoption times are -0.293 and -0.306 for the stock of adopters and exposure to extension services, respectively). In contrast, distinct with exposure to extension, geographical proximity is a very important element of informational transmission among the population of farmers. Finally, the interaction term between the two channels of information dissemination was found to have negative and statistically significant effect. This result indicates that extension services and intra-farm communication channels complement each other in information provision to olive-growers.

This outcome might hinge on the nature of the transmitted information. The study was very comprehensive as it developed a theoretical model and tested it but focused on irrigation technology use and hence motivates further research to particularly examine these information channels in disseminating Integrated Soil Fertility Management technologies.

Langyintuo and Mungoma (2008) provided empirical evidence that examines a non-linear association between wealth and utilization of new agricultural technologies so as to enhance understanding as to whether in a farming setting, farm households with a poorer wealth score act differently from their counterparts on a higher level. Employing statistics collected from a random selection of 300 households in three districts of Zambia, they first classified farm households into poorly- and well-endowed on the basis of their ownership of productive assets and implemented individual double-hurdle models for the use of improved, high yielding maize (IHYM) varieties separately for the two groups. They revealed that the influencing factors of intensity of adoption of IHYM varieties vary between the two groups. This highlights their recommendation of wealth targeted interventions to propagate the intensity of adoption of those varieties and its consequent effects on food security and over-all livelihoods of the households.

Monge and Halgin (2008) analysed the role of change agents and social capital to the use of innovations among small farm households through social networks in rural Bolivia. Three hundred and sixty farmers involved in the targeted networks and 60 change agents and other actors propagating the dissemination of innovations were interviewed. Their study found persuasion, social influence and competition to be statistically significant influencing factors of farmers' use of innovation. Their findings tend to engage policy attention especially the incorporation of social capital and networks in the design and execution of policies on agricultural innovations. However, the study did not directly deal with the nexus between adoption of soil fertility management practices and social networks in Ghana.

Nkegbe *et al*. (2012) investigated the determinants of intensity of adoption of six conservation practices *viz*. stone bund, soil bund, grass strip, agroforestry, cover crops and composting using 445 households' data across 15 rural settings in northern Ghana. They employed univariate, bivariate and multivariate probit models and their findings showed the key adoption factors to be plot and cropping characteristics such as location; and socio-economic and institutional variables including number of contacts with extension officers, membership in farmer association and distance to major market. Their study implies that building the capacity of extension service in the area can greatly influence conservation adoption. However, the study, with the exception of farmer association membership variable, neglected the critical contribution of participatory extension approaches such as social networks in the diffusion of agricultural technologies. The paper, however, gives a good support to the development of the literature on adoption studies, especially in Northern Ghana.

Lambrecht *et al*. (2014) presented a study on gender distributed programme participation and concluded it leads to higher use rates with females not taking part in the use of capital-intensive technologies whereas females were not to be participating more in labour-intensive technologies. In their conclusion they noted that selecting female-headed households guarantees high effectiveness for technology use than selecting female farmers under male-headed households. Though this is a unique and one of the scanty studies that explored the gender dimension of adoption of agricultural technologies it did not consider the major technology dissemination channels such as social networks across the gender divide.

Mponela *et al*. (2016) examined the factors influencing the adoption of integrated soil fertility management technologies small-scale farmers in the Chinyanja Triangle of Southern Africa. They employed cluster analysis to classify the technologies as well as ordered probit to investigate the tendency of several technology adoption. Their study revealed that adoption of ISFM is classified into 3 technological categories depending on complementarities. The nutrient dense category of technologies is inorganic fertiliser, compost and animal manure (ISFMset3). The other technological group consisting of fallow, rotation and grain legumes (ISFMset2) which promotes biomass accumulation and nitrogen fixation with complementary effects in cereal dominated farming system, has more potential to be used by farmers with land that needs high inputs, are relatively highly educated, tend to possess more bicycles and have advanced financial capital. Other four technologies (ISFMset1 including mulch, lime, compost and agroforestry) are used by a few individuals to address explicit constraints in nutrient and water retention, and acidity. Their study is very useful to the current study but did not deeply explore the consequence of social learning for ISFM adoption.

Kokoye *et al*. (2016) assessed the use and the socio-economic effect of adopting Soil Conservation Practices especially on farm income in Northern Haiti as a result of agricultural productivity increase. With data collected on 483 farmers in six watersheds in Northern Haiti, they used the Heckman two steps selection model for their analysis. Their study demonstrated from the probit model that gender of farmer, membership of farmer groups, land ownership, access to credit, the interface between education and group, the size of the plot and the interaction between slope and the size of the plot are key determinants. The outcome model of the Heckman selection displays household size, access to credit and off-farm activities improve farmers' income as significant. But the study failed to make any policy recommendation on adoption and had some model identification challenges as the same explanatory variables were included in both the selection and outcome models which can impair the reliability of the estimates.

Abdulai (2016) adopted a distinct time duration model to comprehend the role of peer effects through farmers' social and institutional networks as well as farmers' risk attitude in the use and diffusion of conservation agriculture technology. The results from a principal components analysis revealed that farmers' years of education, risk appetite, social networks, access to credit, extension services and machinery as well as soil quality positively affect adoption and diffusion of conservation agriculture technology. This was very interesting but failed to capture the effect of the adoption of the conservation agricultural technology on crop yield which also influences adoption of the technology. In this current study, there is a link between soil fertility management adoption and crop yield.

Mango *et al*. (2017) studied the level of responsiveness and use of land, soil and water conservation practices in the Chinyanja Triangle, Southern Africa. Data for this study was collected from 312 households using a survey questionnaire. They employed t-tests to categorize adopters and non-adopters of soil, land and water conservation measures and binomial logit models. Their study found the household head's age, education, agricultural advice reception, farmer group membership, pieces of land-owned or used in production and land-to-man ratio as major determinants of decisions to adopt. Based on the findings, they drew the conclusion that to uphold and enhance land productivity, importance should be placed on farmers' heterogeneity with respect to household head's age, level of education, extension services outreach, and socio-economic characteristics. This advocates that governments' policies initiatives should target improving farmers' level of education, extension delivery that will target the elderly and the youth, landownership, credit access, and social capital such as group formation. With respect to landholding, their results are consistent with Oostendorp and Zaal (2012) who concluded that earlier adoption studies employing duration or panel data have concentrated on the role of different changing village and household-level determinants and highlighted the importance of land ownership changes. As a corollary, the study proposes that policy-makers should focus on the important role of land market changes for investment in land. This informs the incorporation of land tenancy and plot characteristics as some of the influencing factors of adoption in the current study.

Moges and Taye (2017) analysed the significant influencing factors of farmers' perception which motivate their adoption and investment in Soil and Water Conservation (SWC) technologies in Ankasha District of Ethiopia. They surveyed 338 households drawn in a random selection from two rural sample kebeles (called villages here after). Descriptive statistics and results from logistic regression model demonstrated that educational status and level of access to trainings are seen to have a positive and highly significant relationship ($P < 0.01$) with farmers' perception. Likewise, household ownership of land, plot size, slope type, and extension contact have positive and statistically significant effect on farmers' perceived understanding on the need to use soil conservation practices at 5% level of significance. Likewise, the effects of farmers' age and distance to plot from the homestead have statistical significance and negative effect ($P < 0.05$). Overall, the findings suggest that the perceived need for farmers to incur reserves in Soil and Water Conservation technologies is highly influenced by socioeconomic, institutional, attitudinal and biophysical determinants. Thus, consistent contacts between farmers and extension agents and frequent agricultural trainings are also required to raise sensitisation on the impacts of Soil Water Conservation benefits. This recommendation forms the foundation of the present study to establish whether farmer-to-farmer extension and contacts with extension agents are critical factors that impacts on adoption of soil fertility management technologies or not.

Kpadonou *et al*. (2017) performed a combined analysis of the determinants of on-farm soil and water conservation technologies in West African Sahel by implementing a combined analytical approach of both multivariate and ordered probit models. They selected 500 farmers and their study emphasised that the significant determinants of farmers' adoption decisions and to emphasise the utilisation of most SWC practices are the presence of children (aged 6 to 14) within the household, land holding, land tenure, awareness and training on SWC and access to alternative – but non-agricultural labour constraining – cash sources such as remittances. Higher migrant household members increase the likelihood of the household increases the use of SWC practices, but only when this is in line with the household's land benefaction and labour needs for farm activities. This comprehensive study will be of significance for a finer understanding of SWC practices in West African Sahel. Overall, they recommend the findings of their study should inform policy prescriptions on promoting SWC practices.

Mekonnen *et al*. (2018) studied the existence of social learning in agriculture in Ethiopia. They proved that kinship or group membership and organising regular meetings with network members are all related with an increased propensity of establishing an information link with a network member. Furthermore, they found evidence of the presence of positive and significant linkage among networks and the use of row planting and yields for both male and female networks. On the other hand, they provided evidence to suggest that the hypothesised inverse U-shaped association of social learning, that is, between the number of adopters in the network and the adoption of row-planting, is quite higher for female networks. The implication of their findings is that extension services and other associated programmes that aim at encouraging the adoption of agricultural technologies and looking for yield improvement can benefit from social networks but that their success depends on figuring out the ‘‘right” networks, such as those of female household members in the context of row-planting.

2.5 Measuring Welfare

Welfare is commonly proxy by measures of consumption or income. However, in recent years, the use of asset-based wealth indices as an alternate metric measure of welfare has become increasingly noticeable (Walks, 2016). Indeed, wealth indices signify the only way to examine distributional aspects in uniquely detailed large-scale surveys – such as MICS (Multiple Indicator Cluster Surveys) and DHS (Demographic and Health Surveys) – that absence of information on income and/or consumption (Smits, 2015)

The wealth index occasionally has, and also more recently, been considered a theoretically and basically superior alternative measure of economic status to income and consumption (Abreu, 2013). Wealth better replicates long-term welfare as it is less unstable than both income and consumption. It is considered more appropriate to analyze multi-dimensional poverty (Poirier, 2020; Menon, 2016; Walks, 2016), and finally, it is less data-intensive and therefore at ease to calculate (Abreu, 2013; Smits, 2015; Ghosh, 2013).

However, these structures make the wealth index a specific indicator, and as such, it cannot be equal to the orthodox measures of economic status. Different studies report that the asset index is, in fact, a generally poor proxy for current household income or expenditure (Ghosh, 2013), while it may be a good substitution for long-term or permanent income. Furthermore, many conceptual and logical reasons limit the use of asset-based indices as alternative measures of welfare (Abreu, 2013).

First of all, the wealth index provides a comparative measure of welfare – namely a household's wealth is measured relative to other households in the sample – but does not compute the household's current levels of welfare or poverty (Menon, 2016).The wealth index, as most frequently constructed, has also been found to have an urban bias and limited biased power at the lower end of the wealth distribution (Howe, 2012; Cook, 2021). Moreover, variations in price levels across regions are not taken into account in the asset-based approach (Howe, 2012) and the quality of assets is ignored. Weights on individual indicators are not deal with theoretically (Cook, 2021), and the suitability of the wealth index is likely to vary across sub-groups of the population. Depending on the purpose of the study, the indicators included in the index might have direct effects on the outcome of interest (Abreu, 2013; Ghosh, 2013). Lastly, considerable concerns arose about the use of the wealth index for welfare comparison over time and across countries. Although contemporary studies have offered methodologies to allow for inter-temporal and intraregional comparisons (Ghosh, 2013; Smits, 2015; Walks, 2016), they do not persuasively overcome the observed limitations.

Therefore, for a sequence of theoretical as well as concrete reasons, the wealth index cannot be used as a perfect substitute for income or consumption which, among other considerations, remain the most common and established measures of welfare (Échevin, 2013).

Researchers have debated strongly on the strengths and weaknesses of different welfare indicators with a fairly clear consensus on supporting consumption over income, specifically in a developing country context (Aitken, 2019). In the first place, individuals derive material well-being from the genuine consumption of goods and services rather than from the receipt of income per se (Cook, 2021); therefore, consumption expenditure appears to capture the concept of 'standard of living' better. Deaton and Zaidi (2012) contend that consumption better reveals long-term income as it is not closely tied to temporary variations in income and is smoother and less adjustable than income. Income is more likely to be affected by seasonal arrangements resulting either in an underestimation or overestimation of real income. Consumption is more stable, particularly in agricultural societies as it is smoothed over the seasons, therefore better replicating (or approximating) the actual living standard.

Moreover, although collecting data on consumption expenditure is usually very time consuming, the concept of consumption is usually more obvious than the notion of income (Aitken, 2019). For this reason, it is complex to accurately measure household income, especially for independent households and those working in the informal sectors (Ghosh, 2013).

Finally, income is probable to be a more sensitive concern for respondents than consumption (Howe, 2012): there is some indication that those who are wealthy are less likely to participate in the survey or to respond; this results in an underestimation of income inequality among the population (Menon, 2016). Hence, this study engaged the concept of consumption expenditure and income (though has limitations) as indicators for welfare.

Although the term poverty is one of the daily words that people use, it is not straightforward to provide a universal definition of the term due to its complexity (Béné, 2014). While some definitions look at the concept in monetary terms, others define it in non-monetary terms; thus it is challenging to find a general definition on the term. This has been the reason for terms such as income poverty, economic poverty, nutritional poverty, social poverty and human poverty (Bayat, 2020). According to UNDP (2000), the two main dimensions of poverty as a concept are income and human poverty although the former can be regarded as a traditional measure. For instance, the renowned international poverty line of US $1 a day that is used to monitor progress against the MDG goal of reducing extreme poverty (Chen and Ravallion, 2012) involves the connotation of income poverty.

The common definitions of poverty include: (1) the absence of command over commodities in general (Sen, 1977; Ravallion, 2011), or (2) the absence of or the failure to attain a socially satisfactory standard of living (Deaton, 2011). Poverty covers insufficient income and denial of the basic necessities such as education, health services, clean water and sanitation (World Bank, 2007) which are vital for human survival and dignity. UNDP, 2013, states that poverty primarily involves deficiency of access to income, employment opportunities, and normal inner entitlements by the citizens. According to Akerele and Adewuyi (2011) poverty is one of the most considerate expressions of human denial and is intimately related to human capital development.

Due to the multidimensional nature of poverty definition, it is commonly associated with „wellbeing" (welfare). In other words, poverty is the flip side of welfare and is defined by World Bank (2000) as a noticeable denial in wellbeing. Wellbeing in this regard is the capacity to have maximum control over commodities/resources. Therefore, people are better off if they have a greater control over resources that meet their needs such as food, health, shelter, education and social status. Maybe the widest approach to wellbeing is the one articulated by Sen (1987), who argues that wellbeing emanates from a capability to function in society. Thus, poverty arises when people lack key capabilities that lead to insufficient incomes; education; poor health; insecurity; low self-confidence; or low sense of humanity.

In general, poverty is determined by comparing individuals‟ income or consumption with some distinct threshold (poverty line) below which the individuals are considered to be poor. This has been the most conventional view and provides the initial point for most analyses of poverty (Aitken, 2019). This threshold is grounded on the cost of survival needs in a given country and therefore determines the border between poverty and non-poverty (Howe, 2012). This means that an individual is considered poor if his/her available resources are below a median/mean subsistence living. For instance, the World Bank uses $2.00 per day as a median poverty line for all developing countries (Abreu, 2013). In Ghana, GSS (2014) defined extreme (lower) poverty line at GH₵792.05 per adult per year (equivalent of $1.10) and absolute (upper) poverty line at GH₵1,314.00 per adult per year (equivalent of $1.83). There is a growing consensus that the relationship between income and measures of welfare is not as strong as it might appear at first examination. Critiques of this threshold approach are Reddy et.al, (2010), Townsend (2002) and Fischer (2018) who argued that the poverty line appears arbitrary and its undertone does not sufficiently anchor on any specification of human requirements.

There are two basic types of poverty; relative and absolute. Relative poverty is the phenomenon where a person’s resources fall in an unacceptable distance from the average or median. Absolute poverty on the other hand is the condition of being incapable or only hardly able to meet the subsistence fundamentals of food, clothing, and shelter" (Todaro and Smith, 2011). Poverty is not a static phenomenon but may change with time; either increasing or decreasing. Laderchi, Saith and Stewar (2003) observed that the poor usually live without fundamental freedom of action and choices. They often lack basic life necessities and assets that expose them to face deficiencies that refute them the kind of life seen as decent. Similarly, they are every so often exposes to ill behavior by state organizations and society and are feeble to influence key decisions affecting their own lives.

2.5.2 Measuring consumption expenditure

Measuring consumption expenditure is a challenging task. Nevertheless, good practical techniques and guidelines exist which may be taken in to consideration when trying to construct a precise measure of expenditure on consumption (Deaton and Zaidi, 2002; and Engman and Farole, 2012). In order to attain a good measure of welfare, consumption should be all-inclusive (Deaton and Grosh, 2000); the questionnaire should cover all mechanisms of consumption and all types of consumption.

Gathering information only on a subsection of consumption could end in bias as Deaton and Grosh (2002) put it "the relationship between the part and the whole can vary a great deal from one household to another and from one place or time to another", therefore the omission of some components could affect the ranking. Consumption usually includes: 1) food consumption, 2) non-food items (including health, education and other non-food expenditures), 3) housing expenditures (including rent and utilities) and 4) consumer durables.

Food consumption: includes food consumed inside the household from a diversity of sources (food purchases, self-produced food, food received as gifts, remittances and payments in kind) and food consumed outside the household (restaurants etc). *Non-food items* refer to education (such as tuition fees, textbooks, etc.), health (medical care and health expenses) and an extensive variety of other non-food expenses (such as domestic fuel and power, tobacco products, clothing and footwear, transport, recreation, personal care, miscellaneous goods and services). A choice, however, has to be made in terms of the items to include. It is usually endorsed to include education expenditures and to exclude taxes and levies as well as gifts and transfers (Streiner, 2015).

The addition of health expenditures is questioned. As highlighted by Deaton and Zaidi (2002), it is cumbersome to measure the increase in welfare emanating from health expenditures, as information would be required on the loss of welfare from illness on one hand and on the rise in welfare from its mitigation on the other. If health expenditures only are accounted for, then differences between two sick people – of whom only one is able to pay for treatment – are missed. The recommendation is to include or exclude these expenditures grounded on the analysis of the elasticity of health expenditures with respect to total expenditure (inclusion is suggested when the elasticity is high).

The inclusion of cumbersome and less recurrent expenditures – ceremony-related such as marriages and dowries, births, and funerals – is also a subject when trying to capture consumption. These expenditures are usually not included in the consumption aggregate given their 'idiosyncratic nature and infrequency' (Beegle et al., 2010). Gathering this kind of expenditure is, in fact, likely to end in bias as there will be households that have incurred this type of expenditure in the reference period and others who did not - even though they might have spent on these same items in a previous period (Streiner, 2015). Housing expenditure encompasses actual rent or rental equivalence value, house repair, decoration and so on (Andrews, 2011).

Rents can occasionally be observed directly (i.e. households that rent their dwelling); for households that do not report rents (i.e. owner occupiers), respondents can be asked to provide an approximation (or rental equivalent); another approach is to predict rental payments through the use of imputation models (i.e. by hedonic regressions). Both procedures, however, work well only where an active rental market is in place. Moreover, the reliability of imputation models can be simply compromised when only a small or misleading part of the population rents (Fuerst, 2011; Andrews, 2011).

Finally, another imperative group of items to consider is *consumer durables*. When dealing with durable goods (such as home, vehicles, washing machine, computers, etc.) what should be computed is not the expenditure itself but the movement of services that they yield. However, in order to compute this flow of services for durable goods, information is required on the age of each durable good as well as on its original and current value; in practice, appraising the value of service flows also involves crucial expectations such as definition of durable good, depreciation rate of diverse items and so on (Andrews, 2011; Smits, 2015).

2.6 Theories Underpinning Impact Assessment

The theoretic fundamentals of impact evaluation are diverse and developing (Morgan, 2012). However, they mainly revolve around programme theory or the theory of change advanced by Weiss (1972). In the works of Msila and Setlhako (2013), Weiss defines the purpose of evaluation as a process “to measure the effects of a program against the goals it set out to accomplish as a means of contributing to subsequent decision making about the program and improving future programming" Therefore, programme theory defines a variety of means of developing a underlying model linking programme inputs and activities to order of projected or observed outcomes, and then using this model to guide the evaluation" (Funnell, 2011). Alternatively, programme theory refers to the causal relationships along an impact pathway (Mayne and Johnson, 2015). As presented in Figure 2.2, an impact pathway narrates inputs/activities (i.e., interventions such as a project, programme and policy) to predicted outputs (such as increased or decreased production, consumption, welfare among others) to outcomes (e.g., production, income, expenditure among others) and eventually to impacts on long-term changes in wellbeing such as decrease of poverty and hunger, or improved health and nutrition. Impact evaluation pays attention on the long-term effects of the project, programme or policy. Fundamental to the impact pathway are various drivers that affect the efficiency and effectiveness of the conversion of interventions to impacts along the intervention-impact results chain. These influences constitute "external factors" or the "supra-environment context" and are categorized by biophysical, economic, socio-cultural and idiosyncrasies that interact and anchor the intervention (Matchaya, 2014)

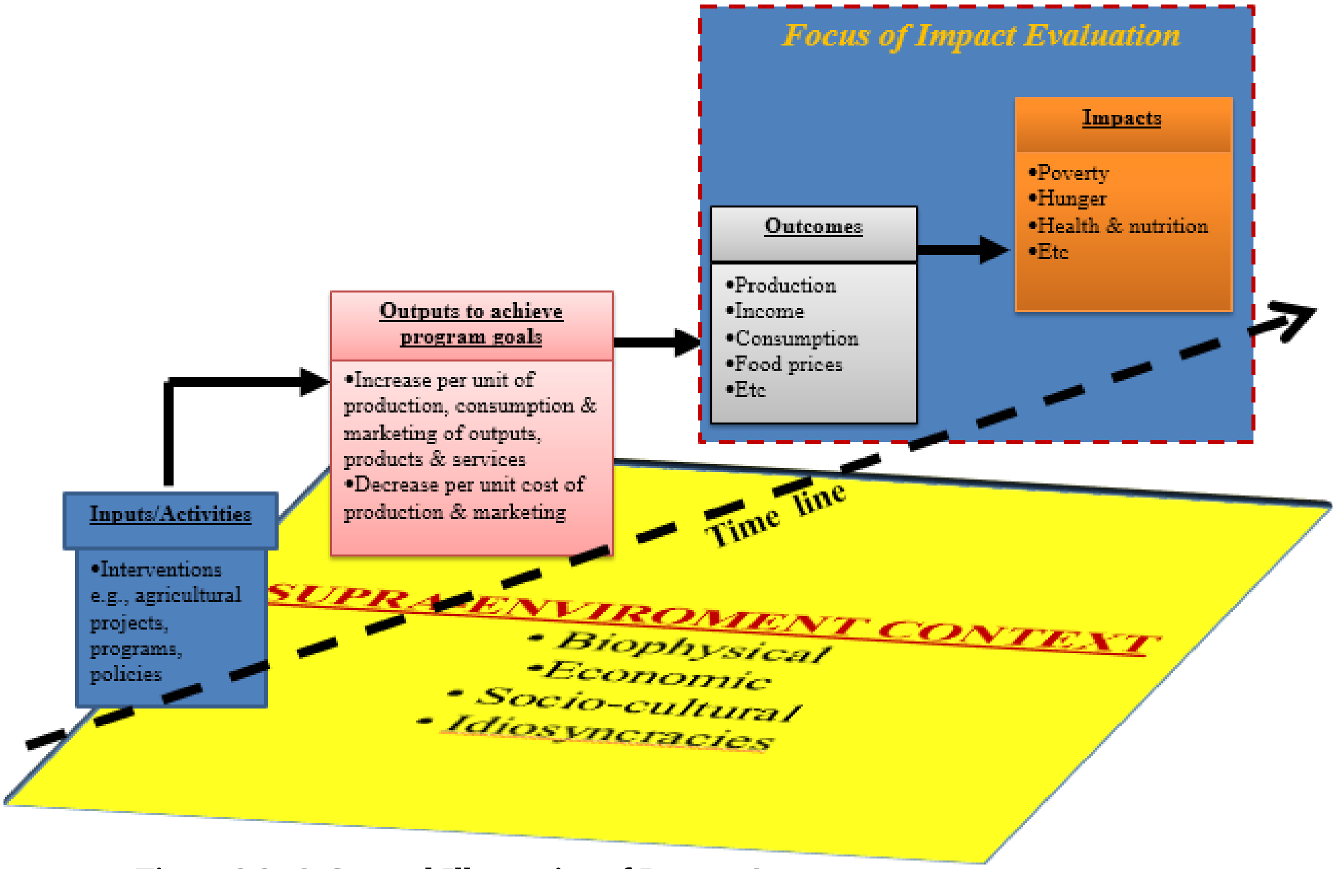


Figure 2.2: A General Illustration of Impact Assessment

In addition, impact evaluation encourages accountability in the dissemination of scarce resources. Impact evaluation aids policy makers to clearly understand the effects of individual interventions and guides future evaluations of associated interventions (Matchaya, 2014).

The theory and practice of impact assessment has persistently established ever since the inception of the National Environmental Policy Act of 1969 (NEPA) in the USA (Pope *et al.*, 2013). This legislation was predominantly accepted as a political response to the varying nature of industrial development of post-World War II and increasing public concerns about the environmental consequences of economic development (Pope *et al.*, 2013). The first formal Environmental Impact Assessment (EIA) system was established on the 1st January 1970 by the NEPA (Cashmore et.al, 2012). Over the last 15-20 years, EIA has extended reputation at the international level as a result of rising concerns about loss of biodiversity, threats to fresh ground and surface water sources and water quality, damage to marine zones and other forms of global environmental change (Morgan, 2012).

Ever since the commencement of EIA in the USA, a number of precise forms have been advanced as a result of some disapproval with transferability of the EIA. These include health impact assessment (HIA), strategic environmental assessment (SEA), social impact assessment (SIA), policy assessment and sustainability impact assessment (Pope *et al.*, 2013). HIA originated as a reaction from many public health professionals that EIA did not adequately address such areas as project impacts on community and individual health (Taylor *et al.*, 2004). Harris-Roxas (2012) noted that HIA originated from three distinct but related areas of public health, namely, environmental health, the wider elements of health and health equity.

Environmental health centers on possible health risks associated with major projects. Over the years, it has been acknowledged that non-health sector activities implicitly determine human health outcomes (Harris-Roxas, 2012). SIA was advanced in the late 1970s and 1980s because EIA was deliberated to have a strong biophysical emphasis, at the expense of social impacts (Morgan, 2012). Originally, SIA was used as a technique for predicting social impacts as part of EIA. Today it is used as a process of analyzing, monitoring and managing the social consequences of planned interventions (Esteves et.al, 2012). Sustainability assessment is defined as any process that directs decision-making towards sustainability. This definition covers many potential forms of decision-making from choices of individuals in everyday life through to projects, plans, programmes or policies more closely addressed in the fields of impact assessment (Bond *et al.*, 2012; Morgan, 2012). Sustainability assessment uses analytical and participatory approaches aimed at combining environmental and associated social-economic considerations into policies, plans and programs (Bond *et al*., 2012).

SEA includes identifying and evaluating likely impacts of policies, plans and programmes (PPPs) and keeping more sustainable patterns of development (Tetlow and Hanusch, 2012). Globally, SEA has been functional for identifying and evaluating potential impacts of PPPs in order to promote sustainable patterns of development (Pope et al., 2013). SEA is worthwhile in many levels of planned activity (legislation, lending, policies, plans and programmes). It can be applied to a specific geographical area (national, regional, local), a specific sector (spatial planning, transport, agriculture, forestry, fisheries, energy, waste/water management, tourism) or to a precise issue (climate change, biodiversity) (Tetlow and Hanusch, 2012).

Policy assessment attempts to notify decision-makers by predicting and evaluating the probable impacts of policy options (Adelle and Weiland, 2012). It appeals on the same standard steps as EIA and SEA by identifying the problem, defining objectives, identifying policy options and analyzing impacts. Based on this literature, this study is a combination of SEA and policy assessment impact.

2.6.1 Methods of impact evaluation

In impact evaluation studies, the variable (outcome) of interest is a function of observable and unobservable features of the population and whether or not the population participated in the program in question. In measuring the impact of a given program on the outcome, there is a need to cater for all observable and unobservable influences. Failure to control for these factors might lead to bias results. In order to deal with the issue of selection bias, the standard analytical methods of impact evaluation include: Heckman two step and instrumental variables (Kassie et al., 2011).

The Heckman two-step is built on the assumption that errors are normally distributed while the Instrumental Variable method draws on the identification of valid instruments. Both methods address the problem of self-selection by introducing/striking distributional and functional form assumptions. The imposition depends on a linear functional form of the outcome equation and an extrapolation over regions of no common support, for treated and non-treated (control).

Contrary to the Heckman two-step and Instrumental Variables methods, the Propensity score Matching (PSM) does not inflict distributional and functional form assumptions. Rosenbaum and Rubin (1983) developed the propensity score matching (PSM) method. The leading drive for using the matching was to find a group of treated respondents (perennial crop producers) similar to the control group (non-perennial crop producers) in all relevant pre-treatment characteristics, with the only difference being that one group participated in the given project intervention and the other did not.

The Conditional Independence Assumption (CIA) and the Common Support Condition (CSC) are the two main pre-requisites of the PSM. The CIA means that the selection into the treatment or participation group is only based on observable characteristics. In addition, the treatment effect on the outcome variable, which is income (in this study), can be explained by these observable characteristics. The common support condition requires that the Average Treatment Effect for the treated (ATT) is defined within the region of common support ensuring that households with the same observable characteristics have a positive probability of being both treated (adopters) and non-treated (non-adopters) (Heckman, Ichimura, & Todd, 1997). The Propensity Score Matching is a two-step methodology. First, a probability model for adoption of the new technology is estimated in order to get the propensity scores of adoption for each household. Second, in order to estimate the ATT, each household adopter is assigned or matched to a household non-adopter with similar propensity score.

Matching methods exist to match adopters with non-adopters. The common methods used are the Nearest Neighbor Matching (NNM) and the Kernel-Based Matching (KBM) (Becerril & Abdulai, 2011). The Nearest Neighbor Matching method consists of matching adopters with non-adopters having the closest propensity score. The Nearest Neigbour Matchning can be grouped in to Matching with replacement and Nearest Neighbor without replacement. Matching with replacements enables one comparison unit to be matched more than once with each treatment unit when there are few comparison units (Danso-Abbeam, 2019). However, matching without replacement forces the matching between the treatment group and the comparison one that are quite different in propensity scores. This has the tendencies of leading to bad matches, which increases the bias of the estimator. The Kernel-Based Method involves matching treatment group with weighted average of all non-treatment (control), which is inversely proportional to the propensity scores of treatment and the control group (Frölich, 2017)

In addition, two additional matching procedures are used in order to understand how sensitive the results can be: Radius matching and stratification matching. The Radius Matching matches only those control and treatment observations within a pre-defined range on the propensity score. The Stratification Matching divides the propensity score into a set of intervals. It also estimates the average treatment effects on the treated within each interval using the mean difference between the control and treated observations. The number of strata is generated from the propensity score by STATA. The current study uses the Nearest Neighbor Matching with replacement to assess the robustness of the results because the non-treatment sample and the treatment sample are almost equal. The non-treatment sample is quite few compared to the treatment sample.

After matching, the balance test is required in order to compare the before and after matching and to verify if there is no differences after conditioning on the propensity score (Mumin, 2017). Among all the existing balancing tests, the mean absolute standardized bias suggested by Rosenbaum & Rubin (1985) is the most relied upon.

2.6.2 Review of selected impact evaluation studies

Danso-Abeam and Baiyegunhi (2019) studied into whether the use of fertilizer improves household welfare in the Ghanaian cocoa farming industry using the PSM, their study revealed fertilizer application tend to have a significant results in farm yields, farm income, consumption expenditure per capita and value of productive farm assets. Their study concluded that fertilizer use has a significant impact on farmers' welfare and as such technological based initiatives should be improved upon to intensify effective and efficient cocoa management practices. Magrini & Vigani (2014) studied the impact of agricultural technologies (improved seeds and inorganic fertilizers) on food security of maize farmers in Tanzania using a propensity score matching technique. The results indicated that adoption of improved seeds and inorganic fertilizers have a positive and significant bearing on household food security. Gebrehiwot & Veen (2015) studied the impact of a Food Security Package (FSP) programme on households' food consumption in Tigray region, Northern Ethiopia. The FSP programme targets securing food for vulnerable households by diversifying their income base through delivery of credit for specific activities. They employed a propensity score matching approach to estimate the causal effects. Using Kernel matching, they established that the programme enhanced food calorie intake by 772.19kcal/day per adult equivalent unit. Mbamdo, Wale and Baiyegunhi (2015) assessed the welfare impacts of small holder farmers' participation in maize and pigeon pea market in Tanzania using the propensity score matching (PSM) and the endogenous switching regression (ESR). The study revealed that maize and pigeon pea market participation increased consumption expenditure per capita in the range of 19.2-20.4% and 28.3-29.4%, respectively, and therefore concluded that maize and pigeon pea market participation positively influence welfare of rural households. Obisesan & Omonona (2013) measured the impact of the Root and Tuber Expansion Programme (RTEP) on food security of cassava households in Nigeria. Using a propensity score matching method, the authors computed the average treatment effect for the treated to measure impact. The authors found that the food insecurity impact of the RTEP programme of beneficiaries was lower than that of the non-beneficiaries. This suggests that the RTEP has the potential to improve food security. Shiferaw, Kassie, Jaleta, & Yirga (2014) studied the impact of improved wheat varieties adoption on household food security in Ethiopia. Using endogenous switching regression, adoption of improved wheat increased the probability of food security by 2.7% for adopters and 4.5% for non-adopters had they adopted improved varieties.

Khonje, Manda, Alene, & Kassie (2015) studied the impact of improved maize varieties on welfare in Eastern Zambia. They selected crop incomes, consumption expenditure, and food security as welfare indicators. Employing both endogenous switching regression and propensity score matching, they found that adoption of improved maize increased crop income, consumption expenditure, and poverty. The propensity score matching results shows that adoption of improved maize varieties increased crop income per hectare in the range of ZMK52.3 million to ZMK2.4 million (using respectively Nearest Neighbour Matching and Kernel Based

Matching). The adoption increased average consumption expenditure per capita in the range of ZMK271, 122 to ZMK305, 122. The adoption reduces the probability of poverty by 11 percentage points. Using the Endogenous Switching Regression (ESR), the average increment on crop income per hectare for adopters (ATT) is ZMK78,900 and on consumption expenditure per capita is ZMK324,690. Adoption of improved maize varieties reduced the probability of poverty by 21 percentage points for adopters using ESR. Kassie, Shiferaw, & Muricho (2011) measured the impact of improved groundnut adoption on crop income and poverty in rural Uganda. Using propensity score approach, the authors showed that adoption of improved groundnut varieties increased crop income in the range of US$130-$254 and decreased poverty by 7–9 percentage points. Becerril & Abdulai (2010) used a propensity score matching method to measure the impact of improved maize varieties adoption on household income and poverty in Chiapas and Oaxaca regions in Mexico. Using both nearest neighbor and kernel-based matching algorithms, the authors found that adoption of improved varieties increased per capita expenditures and the probability of escaping poverty of farmers.

2.7 Empirical literature on the theory of CMP

Makate et.al, (2016) in their work to demonstrate how crop diversification affect the outcome of climate smart agriculture in rural Zimbabwe, increased productivity and enhance resilience within the framework of CMP observed that crop diversification is a vital climate smart agriculture practice that significantly enhances crop productivity and consequently enhances resilience in rural farming systems. Acheampong (2015) observed through the conditional mixed process that farmers for cassava variety traits revealed a higher preference for the in-soil storage and disease resistance traits of cassava in Ghana. Danso-Abbeam and Baiyegunhi (2020) also observed through the framework of cmp inproved welfare enhances the farmers' technical efficiency and higher and higher technical efficiency translate in to better welfare. Asfaw and Libber (2015) in their work of adaptation to climate change and impact on food security from Niger, revealed throught the framework of cmp that; greater climate variability increases the risk of reducing inputs but reduces the use of modern inputs. In the works of Yussif (2019) on social networks and integrated soil fertility management adoption: effects on maize yields and food security of farmers in northern region revealed that social networks significantly determine the intensity of adoption of ISFM. He also further observed that social networks and the number of ISFM practices adopted have significant impact on maize yields, which impact positively on food security.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter presents the research design and sampling strategy, showing systematically, how the sampled perennial and non-perennial farmers were selected during the data collection. Subsequently, the details of the techniques employed to obtain the required data from the sampled farmers are discussed and ultimately the theoretical and econometric analytical models used to analyze the data are also discussed in detail.

3.1 Description of Study Area

The study was carried out in the northern region of Ghana, which forms part of the northern Savanna zone. The region commands a total land area of 97,702km^2 and it is located between latitudes 8^0N and11^0N. It borders Upper East and Upper West regions of Ghana to the north, Brong-Ahafo and Volta regions to the south and finally Cote D'Ivoire and Togo to the west and east respectively. With the exception of the North eastern corridor and the Gambaga escarpment along the Western corridor, the region is generally low lying. The major natural drainage systems in the region are the black and the White Volta and their tributaries, and also, the Dakar and the Oti Rivers. Agriculture constitutes the main economic activity of the people in the region, employing about 70% of the population (Osabohien, 2019). However, agriculture in this region and Ghana at large is purely 95% rain fed (GSS, 2010). Northern Ghana is prone to highly erratic rainfall pattern, and experiences longer duration of draught that can extend up to 7 months in a year. Rainfall usually starts from April/May and ends in October/November; this is known as the rainy season. The remaining 7 months are mostly dry with minimal or no rain; this is call the dry season. The annual precipitation ranges between 400mm and 1,200mm, with an irregular distribution.

Even though the northern part of Ghana experiences 7 months without rain, the short rainy season can be so intense that flooding can destroy economic crops and also displace livelihoods (Donkor, 2012; Laube, 2011; Kranjac-Berisavljevic, 1999). Continuous growth in population, land degradation and the for intensification of agricultural sustainability have led to declining farm sizes, continuous cropping systems and failure of farmers to adopt appropriate farming practices have also contributed to declining soil fertility, which ultimately have resulted in declining output from both crop and livestock system in the region. All these factors have worked together to characterize northern Ghana with extensive hunger and poverty levels (Azumah, 2017).

Six dominant agricultural districts, where the concentration of perennial crop (cashew and mango) production is dominant are selected for this study. These include; Savelugu, Mion, Yendi, West Gonja, Sawla-Tuna-Kalba and Bole districts which are indicated “sea-blue” in the Figure 3.1;

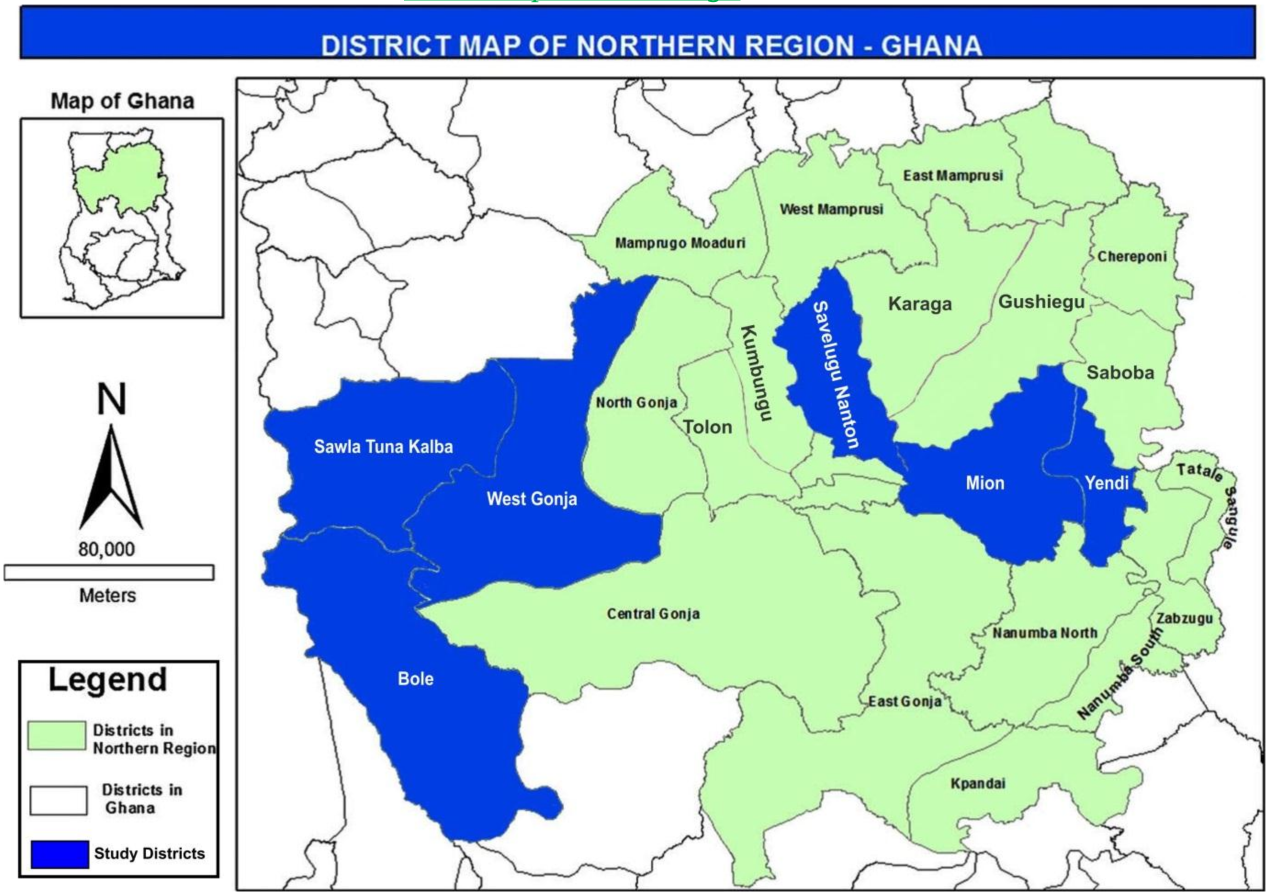


Figure 3.1 Map of Northern Ghana

Fig. 3.1 Map of northern Ghana, depicting districts and study locations, adapted and developed by authors using GIS country data from www.diva-gis.org

3.2 Research Design

Cross-sectional household survey was adopted in this study. The survey included a single-visit to both perennial crop (cashew and mango) and non-perennial crop farmers. The non-perennial farmers are those farmers cultivating food crops such as maize, rice, millet, sorghum, etc. other than perennial crops (cashew and mango). Primary data pertaining to farmers' socio-demographic characteristics, type of perennial crop, income and expenditure as well as sources of livelihoods and types of crops produced in the 2017/2018 farming season was obtained from the sampled farmers.

3.2.1 Sample size determination

Sample size determination for a study from a population has been treated in several pieces of literature including Cochran (1977) and Singh and Chaudhury (1985). The purpose of each determination is to arrive at a precise sample size that can ensure inferences are drawn on the entire population with good precision. The sample size for this study was determined using statistically proven formulae proposed by Cochran (1977) and adopted by Israel (1992). The sample size was determined as follows:

$$n = \frac{\chi^2(1-\varphi)\varphi}{\ell^2} \qquad [3.1]$$

Where n represents the sample size, χ is the z-score from the standard normal distribution table at a given level of confidence, φ is the population proportion and e is the level of precision or margin of error. Grounded on the fact that there is no established data on the population of perennial crop farmers, 50% conventional rate of the population proportion was set, which is expected to be a good representation of the population. A margin of error of 5% was allowed with a corresponding confidence interval of 95%. At the 95%, z-score from the standard normal distribution table was 1.96. The sample was therefore computed from equation [3.1] as follows;

$$\frac{1.96^2(1-0.5)(0.5)}{0.05^2} = 384.16 \cong 384$$

Therefore, the sample size for the study is approximately 384 farmers (both perennial and non-perennial crop farmers). But to cater for risk in arriving at the required sample size, 400 set of questionnaires were administered but 386 was used for data analysis after the data was cleaned. The remaining number was reported missing or damaged.

3.2.2 Sampling and data collection techniques

The selection of respondents for the study involved the multi-stage sampling technique. Six (6) districts noted for their production of perennial crops (cashew and mango) were purposively selected in the first stage from Northern region of Ghana. In the second stage, cluster and simple random sampling technique was used to select six farming communities from each district, making a total of 36 communities. The district offices of Ministry of Food and Agriculture (MoFA) assisted in the selection of the perennial and non-perennial communities. Finally, 10 - 12 respondents were selected using the simple random sampling. This gave total sample size of 400 respondents. However, 386 questionnaires were used for the data analysis.

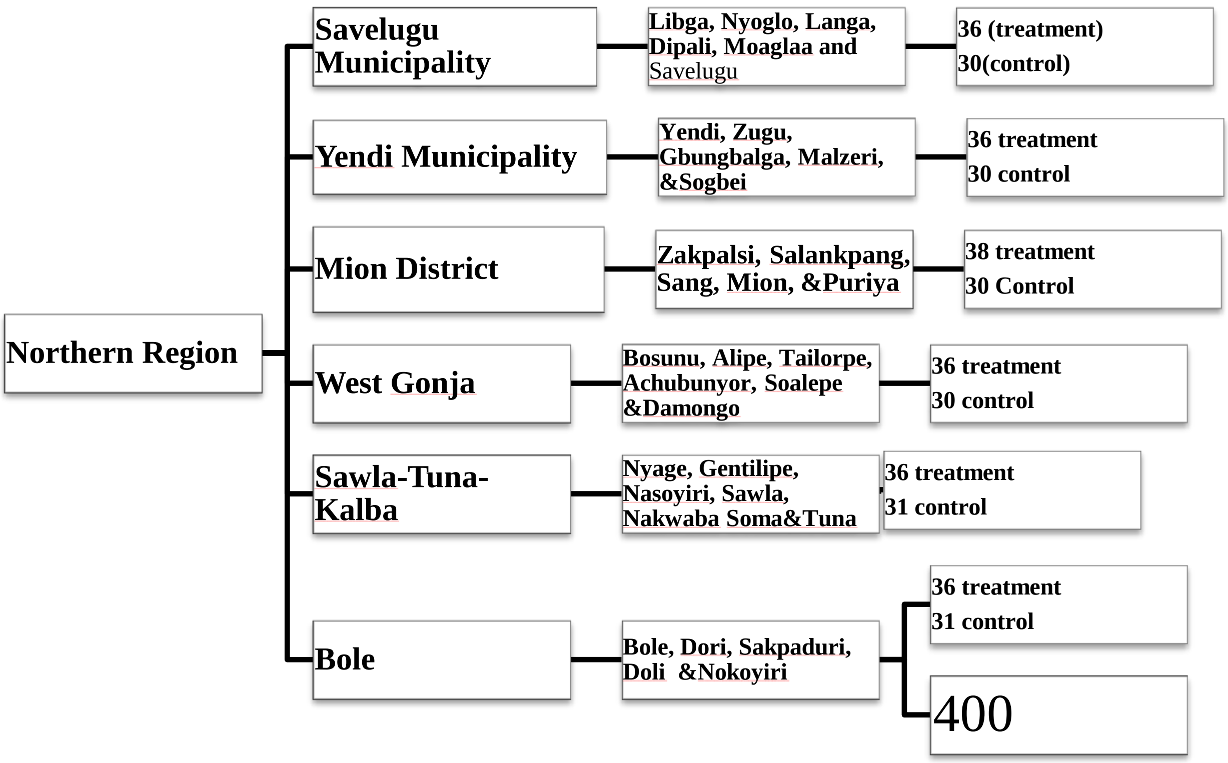


Figure 3.2 shows the diagrammatic presentation of the sampling technique.

Source: Authors' contract, 2019

The data was collected using a semi-structured questionnaire (see Appendix I) with face-to-face interviews. The questionnaire gathered information on the household heads' socio-economic characteristics, type of perennial crops, income and expenditure of farmers, and various sources of livelihoods. A total of 12 enumerators were recruited (two from each district) and trained by the author. A pre-test survey was done, and thereafter information was collected using the local dialect language (Dagbanli) in January 2019. The survey targeted perennial crop farmers as well as farmers who do not cultivate perennial crops but only annual crops. The questionnaire took an average 45 minutes to complete. The principal local dialect employ in various study areas were; Dagbanli, Gonja and Twi.

3.2.3 Data analysis

The data collected were captured and analyzed using STATA version 14. The analysis included both descriptive statistics and econometric modeling. Descriptives and inferential statistics such as means, standard deviations, and frequencies were computed in STATA to show the distribution of perennial crop production across various study area. The means between socioeconomic variables of perennial crop farmers and non-perennial crop farmers were generated and compared using a t-test, and frequencies were compared using a chi-square test. The Propensity Score Matching (PSM) approach was thereafter applied to estimate the impact of perennial crop production on household consumption expenditure per capita. Other econometric models used in study were the bivariate probit model and the conditional mixed process (CMP) framework to analyze choice of perennial crops and the impact of perennial crop production on food security through livelihood diversification, respectively. The results were presented in tabular and graphical formats.

3.4.0 Theoretical Framework

This section outlines the theoretical specifications of the econometric models that underpin the objectives of the study and the justification for their use in this study.

3.4.1 Choice of perennial crop

Several pieces of literature have analyzed crop production or choice of crop production by farmers across the globe, with northern Ghana not being an exception. Majority of these studies, however, focuses on univariate or tobit regression to assess the determinants of crop production or technology adoption with socio-economic factors as independent variables (Rahman and Chima, 2015, Sekyi, 2017, Akudugu, 2012, Ayirezang, 2015 and Fernando 2015). The underlining theoretical basis for such modeling is the theory of utility of rational farmers which is explained as follows. The studies denote the cashew production as pc and, mango production as ac with $p=1$ for cashew, and $p=2$ for mango. The basic utility function in terms of preference of the i^{th} farmer is assumed to be a function of farmer and farm characteristics Z and stochastic term with zero mean as follows;

$$U_{i1}(Z) = \beta_1 Z_1 + \varepsilon_{i1} \quad [3.2]$$

$$U_{i0}(Z) = \beta_0 Z_i + \varepsilon_{i0} \quad [3.3]$$

For cashew and mango respectively. Due to the random nature of the utility derived from cashew/mango cultivation, the i^{th} farmer will only produce cashew/mango if and only if the utility attained from any one (say cashew) of these two (2) crops is greater than the other (say mango), i.e.. $U_{i1} > U_{i0}$.The probability of the i^{th} farmer cultivating cashew is given by:

$$P(1) = P(U_{i1} > U_{i0}) \quad [3.4]$$

$$P(1) = P(\beta_1 Z_i + \varepsilon_{i1} > \beta_0 Z_i + \varepsilon_{i0}) \quad [3.5]$$

$$P(1) = P(\varepsilon_{i0} - \varepsilon_{i1}) < (\beta_1 Z_i - \beta_0 Z_i) \quad [3.6]$$

$$P(1) = P(\varepsilon_i - \beta Z_i) \quad [3.7]$$

$$P(1) = \varphi(\beta Z_i) \quad [3.8]$$

Where ϕ the cumulative distribution function for ε_i and (ϕ) depends on the assumptions made on the error term ε_i, which is assumed to be normally distributed in a probit model.

A single-equation probit method can be used to separately estimate the two equations consistently. However, this approach ignores the correlation between ε_{pc} and ε_{ac} of cashew and mango, respectively. Thus, this rends the approach ineffective (Green, 2003). In other to avoid this limitation, the bivariate probit model was applied. This is based on the mutual distribution of the two normally distributed variables which is specified as follows:

$$f(pc, ac) = \frac{1}{2\tau\sigma_{pc}\sigma_{ac}\sqrt{1-\rho^2}} \ell^{-(\delta_{pc}^2 + \delta_{ac}{}^2 - 2\rho^{\varepsilon} dv^{\varepsilon} ac)/(2(1-\rho^2))} \quad [3.9]$$

$$\varepsilon_{PC} = \frac{PC - \mu_{PC}}{\sigma_{PC}} \quad [3.10]$$

$$\varepsilon_{ac} = \frac{ac - \mu_{ac}}{\sigma_{ac}} \quad [3.11]$$

Where ρ represents the correlation between pc and $ac.\sigma_{pc.ac} = \rho_{pc.ac}\sigma_{ac}$ is the covariance, while $\mu_{pc}\mu_{ac}\mu_{pv}$ and σ_{ac} are the means the standard deviation of the marginal distributions of pc and ac respectively. The distribution is independent on the condition that $\rho = 0$. The most appropriate technique of estimating bivariate probit model is full information maximum likelihood.

3.4.2 PSM: Impact of perennial crop on welfare of farmers

The critical research question to be addressed here is: what impact do perennial crops have on farmers' welfare in the Northern region? It can be observed that the basic concern of most research questions is impact evaluation (Markwei and Appiah, 2016). On a wider perspective, reverence is usually made to the social, economic and environmental implications in an attempt to analyze the impact of any intervention. Within the context of this study, impact refers to the economic implications that emanate from the cultivation of perennial crops (cashew and mango). That is whether the cultivation of perennial crops (cashew and mango) has the desired outcome on the welfare and food security status of the households as against those cultivating annual crops such as rice, maize, sorghum, millet, among others.

It worth acknowledging that creating a counterfactual is very necessary in impact evaluation. A hypothetical scenario of would be situation in the absence of a given intervention is what is referred to as a counterfactual. That is, what would have been the impact in the absence of the treatment or the intervention? In this study, the treatment variable is the production of perennial crops. Thus, farm households cultivating perennial crops are referred to as the "treated group" and those cultivating food crops are called "the control or untreated group".

Two methods usually come to bear in analyzing impact evaluation – experimental and non-experimental. Experimental method is employed when participation is randomly determined or control over participation is exercised by the researcher. In this situation, a randomly determined group prior to the intervention is excluded from the activity (Duflo and Kremer, 2005). This method, however, cannot be adopted in this study since perennial crop production in agriculture is neither influenced by the researcher nor random. In social science studies like this, the most appropriate impact evaluation method to use is the non-experimental technique.

With the non-experimental methods, a set of techniques that helps in comparison with the treatment group is considered. Some of the techniques employed in this method include; propensity score matching (PSM), difference- in- differences, reflexive comparison and selectivity adjusted approaches.

To analyze the impact of perennial crops (cashew and mango) production on farmers' welfare, we begin with a linear equation:

$$\mathrm{Y}_i = \alpha_0 + \alpha_1 UA + \alpha_2 X_1 + \ell_i \qquad [3.14]$$

Where Y_i = outcome (dependent) variable: farmers welfare measured by real per capita consumption expenditure and per capita income, X_i is a vector representing household characteristics, UA is a dummy, representing 1 if a farmer cultivates perennial crop and 0 if otherwise. e_i is the random error term.

In equation (3.14), the decision to cultivate perennial or annual crop is treated as an exogenous variable on the premise that household engage in perennial crops (cashew and mango) to better their welfare status. This may not be a necessary condition since some farmers may be better prepared to engage in the intervention under consideration. Also, the decision to produce perennial or annual crops may arise from the benefits they both come with, which explains that crop production may not be random, as such, the presence of selection bias, which occurs when the error term of a given selection and outcome equation are influenced by unobservable features. Consequently, the problem of selection may be encountered in an attempt to estimate equation [3.14] with Ordinary Least Square (OLS).

To address the problem of selection bias in impact evaluation, several approaches have been employed. Among them include; the difference-in differences approach (Hristos, 2009), instrumental variable (IV) approach, the Heckman-Two-Stage approach, among others (Scott, 2010). The Heckman-two-Stage approach relies on the restrictive assumption of normally distributed standard error terms. It may not also be easy to identify instruments using the IV approach. Moreover, these approaches have the tendency of imposing linear functional form assumption, which may suggest that coefficients on control variables may be similar for both participants and non-participants (Ali and Abdulai, 2010). Coefficients could however vary, which may render this assumption weak or useless.

Because there are several methods that can estimate causal effects, why should this study use the PSM? One reason is that most publications in the management field rely on observational data. Such large data can be relatively cheap to obtain, hitherto they are almost always observational rather than experimental. By adjusting covariates between the treated and control groups, the PSM allows scholars to reconstruct counterfactuals using observational data. Thus, the PSM can produce an unbiased causal effect using observational data sets.

Second, mis-specified econometric models using observational data occasionally produce biased estimators. One basis of such bias is that the two samples lack distribution overlap, and regression analysis cannot tell researchers the distribution overlap between two samples. The PSM can easily identify the lack of covariate distribution between two groups and adjust the distribution accordingly.

Third, linear or logistic models have been used to adjust for confounding covariates, but such models rely on assumptions on the subject of functional form. For example, one assumption needed for a linear model to produce an unbiased estimator is that it does not suffer from the said problem of endogeneity. Although the procedure to calculate propensity scores is parametric, using propensity scores to compute causal effect is largely nonparametric. Thus, using the PSM to calculate the causal effect is less vulnerable to the violation of model assumptions. Overall, when one is interested in investigating the effectiveness of a certain management practice but is unable to collect experimental data, the PSM should be used, at least as a robust test to justify the findings estimated by parametric models.

In the light of this restrictions, this study employed the propensity score (PSM) matching technique in analyzing the impact of perennial crops (cashew and mango) on farmers' welfare. Unlike the parametric methods of estimation which necessitates that some functional and distributional assumptions are satisfied, the PSM as a non-parametric estimation method overcomes these assumptions. According to Heckman as reported by Becerril and Abdulai (2010), PSM matches the observed outcomes of those who adopt a technology and those who do not adopt referred as the counterfactual through the creation of a randomized experiment conditions to aid evaluate a causal effect in a controlled experiment.

Let D_i depicts a dummy variable such that $D_i = 1$ if the i^{th} farmer cultivates perennial crops and $D_i = 0$ if otherwise. Further, lets represent the potential observed welfare outcomes for both perennial crop farmers and annual crop farmers as Y_{i1} and Y_{i2} respectively. Therefore, $\Delta = Y_{i1} - Y_{i2}$ represents the impact of cultivating perennial crop measure on the i^{th} farmer called the treatment effect. Obviously the Y_{i1} and Y_{i2} of the same perennial crop farmer cannot be observed but rather $Y_i = D_i Y_{i1} + (1 - D_i) Y_{i2}$ making it difficult to estimate the treatment effects of each perennial crop farmer.

PSM is a two-stage procedure. In the first stage, perennial crop is modeled as a choice dependent variable using probit or logit model, after which the propensity score of perennial crop production for each observation is calculated. The perennial crop model can be specified as:

$$p(\mathrm{X}) = \Pr[\mathrm{A}_i = 1 / X] = E[A_i / X]; p(X) = F\{h(X_i)\} \quad [3.15]$$

$$p(X) = \Pr(p = 1) / X \quad [3.16]$$

Where $F\{:\}$ can be a probit or logit model with normal or logistic cumulative distribution function, respectively, and X is a vector of pre-treatment covariates. Equation [3.16] is the probability of receiving treatment or propensity score as defined by Rosenbaum and Rubin (1983). Once the propensity score has been computed, average treatment effect on the treated (ATT) can be estimated by matching each perennial crop producer to a non-perennial (annual crop) producer condition on similar characteristics, which is the second stage. The average treatment effect on the treated is the net impact of perennial crop production on the welfare of the farmers. Consider Y_i as the welfare indicator for perennial crop producers and Y_0 as the welfare indicator for non-perennial crop producers, and then Ai as the perennial crop variable that takes the value of 1 for perennial crop and 0 for non-perennial crop[1]. The ATT would be the difference in the outcome of the treatment group with treatment $\mathrm{Y}_i(1)$ and without treatment $\mathrm{Y}_i(0)$. Following Takahashi and Barrett (2013) average Treatment effect on the Treated (ATT) is estimated by $\tau = E(Y_{i1} - Y_{i2} / D_i = 1)$ and the propensity score which is estimated in terms of probabilities specified as. $P(X) = P(D_i = 1 / X)$. It is, however, important to make

[1] It is important to note that if a farmer produces both perennial and annual crops, the farmers is specifically asked “which of the crops contribute more to the livelihood of the household. Thus, what proportion does each of the two categories contribute to the household income. Based on this, the farmers is assigned 1 or 0.

certain assumptions at this point to put both the relationship of the outcomes and the types of crops cultivated and the expected range of the explanatory variables into perspective. (1): Given the variable X the expected outcomes are independent of the perennial crops production. This, therefore, suggests that $= E[E(Y_{i1} / D_i = 1, \mathrm{P(X)} - \mathrm{E}(Y_{i2} / D_i = 0, P(X)$ (2): For all values, the probability of either cultivating perennial crops or otherwise should be positive; hence providing a guarantee for every perennial crop farmer, a corresponding annual crop farmer in the population and expressed as $0 < P(X) < 1$. The Average Treatment effect on the Treated (ATT) can then be estimated as,

$$\tau = E(Y_{i1} - Y_{i2} / D_i = 1) \qquad [3.17]$$

$$= E(Y_{i1} - Y_{i2} / D_i = 1, P(X)) \qquad [3.18]$$

$$= E[E(Y_{i1} / D_i = 1, \mathrm{P(X)} - \mathrm{E}(Y_{i2} / D_i = 0, P(X) \qquad [3.19]$$

Though there are several matching methods in the literature, the commonest used in welfare effects studies are the Nearest Neighbor Method (NNM) and the Kernel Matching Methods (KMM). The nearest neighbor, which matches each participant with its closest neighbor with similar observed features, can be done either with replacement or without replacement. Matching with replacement results in bias reduction since each treatment group can be matched to the nearest comparison group as a result of a reduction in the propensity score distance. The caliper matching, besides using the nearest neighbor within each maximum propensity score distance can also use all the comparison members within the caliper. Kernel matching tends to use more nonparticipants for each participant, thereby reducing the variance but possibly increasing the bias.

This study shall employ the two matching methods to check the robustness of the results by making a comparison between them.

3.5.0 Empirical Framework

This section outlines the empirical specifications of the econometric models that underpin the objectives of the study and the justification for their use in this study. It also indicates the various dependent and independent variables and their respective measurements

3.5.1 Empirical specification of the bivariate model

The empirical specification of factors that affects the choice of type of perennial crop is presented in equation 3.12 and 3.13 for cashew and mango, respectively.

$$Cashew = \sum \alpha i \mathrm{X} i + \varepsilon i \qquad [3.12]$$

$$Mango = \sum \alpha i \mathrm{X} i + \varepsilon i \qquad [3.13]$$

Cashew and Mango represents the dependent variables in equation 3.12 and 3.13, respectively. In this equation, a farmer who cultivates mango or cashew is assigned the value of one (1) and zero if otherwise. The independent variables include; settlement in years, sex of farmer, household size, annual income, credit access, and distance of farm from home, distance of farm from market, FBO membership and years spent in school $\alpha_1 ....\alpha_0$ are the parameter estimates and ε is the error term in both equations. It is worth noting that both cashew and mango equations share the same independent variables. The basis behind this (bivariate probit model) is to test for complementarity or substitutability of the two crops (cashew and mango). If the correlation between the error terms of the two equations is positive and significant, then the two crops are said to complement each other. Thus, the production of mango is conditioned on the production of cashew and vice versa. However, significant and negative correlation coefficient indicates the two crops are substitutes. Table 3.1 presents the variables to be measured in this model with their a priori expectations.

3.5.2 Empirical specification of the probit model

The following equation is the specification of the variables to be measured using the probit model in estimating the impact of perennial crop production on farmers' welfare

$$perennial = \sum \beta i \mathrm{X}i + \varepsilon i \quad [3.20]$$

Where βi is the parameter estimates and $\mathrm{X}i$ are the independent variables which include sex of the farmer, age, access to credit, distance of farm from home, belonging to an FBO, annual income, and household size, and household labour, years spent in school, non-farm income and total asset value. εi is the error term.

3.5.3 Impact of perennial crop production on food security and livelihood diversification

In line with Braimoh and Vlek (2006), with adjustment to take care of endogeneity, the current study adopted the Conditional Mixed Process (CMP) to evaluate the impact of perennial crop production on food security through livelihood diversification. The individual model estimates were computed and then compared with that of the CMP system estimates for a choice of more reliable results. The argument is that from a methodological perspective, estimations of the impact of perennial crop production on livelihood diversification and then on food security might be subjected to the problem of endogeneity, as perennial crop production and livelihood diversification determinants are inherently endogenous. Hence, to take into consideration the likely influence of unobserved factors which can jointly impact on perennial crop production, food security and livelihood diversification, a recursive system with unidirectional dependency among the endogenous variables is defined and comprises three equations: (3.19) perennial crop, (3.20) livelihood diversification and (3.21) food security. These were jointly performed to account for the potential influence of unobserved factors which can jointly impact on intensity of perennial crop production, food security and livelihood diversification. The main potential of using a recursive system is that it is unnecessary to worry about endogeneity issues of right-hand side dependent variables from the other equations. In fact, in a recursive system, the modelling can be done on the observed data of endogenous variables but not the predicted data (Roodman 2009, 2014).

The first equation (model I) describes determinants of perennial crop production (*Perennial)*, which is dependent on some institutional factors (access to credit, FBO membership and access to extension services), farmer and farm characteristics (sex and age of farmer, income and distance of farm from home). The second equation describes household's livelihood diversification, which depends on perennial crop production, assets value, distance of farm from market, off-farm income and expenditure per capita and control variables (*Control)*. Thus, the perennial crop production variable which was the dependent variable in the first equation becomes a predictor in the second equation. Finally, the food security equation is presented by equation [3.23], which is a function of some socio-economic and institutional variables. The livelihood diversification variable, which is dependent variable in the second equation now becomes an explanatory variable measuring the effects of livelihood diversification on food security. Since, endogeneity has been accounted for with the use of the CMP, the coefficient of the perennial crop variable can be interpreted as the causal effect on the food security. The

Given the OLS and probit regression model assumptions, the final empirical regression model for the CMP system that was estimated was in the form:

$$Perennial_{1t} = \alpha_0 + \alpha_{11}X_{1t} + \varepsilon \qquad [3.21]$$

$$LDI = \beta_0 + \beta_1 perennial_{it} + \beta_{21}X_{1t} + \varphi \qquad [3.22]$$

$$HHDS = \gamma_0 + \gamma_1 LDI + \alpha\gamma_{31}X_{1t} + \vartheta \qquad [3.23]$$

Where $perennial_{1t}$, $HHDs$ and LDI represents perennial crops, Household dietary diversity score (food security) and livelihood diversification, respectively. $\alpha, \beta, and\ \gamma$ are the parameters to be estimated. X_{it} are the matrices of variables and ε, μ and γ are the error terms.

Equations (3.21, 3.22 and 3.23) were estimated using probit, OLS and OLS, respectively, within the framework of CMP. The Conditional Mixed-process framework is a recursive structural system of equations that contains both continuous and discrete variables in the right-hand side models and this has an advantage in obtaining efficient estimates compared to the individual estimation of these equations (Roodman, 2011). In equations 3.20 and 3.22, a careful consideration of the problem of endogeneity needs to be taken care of by accounting for selectivity bias in the in whether a farmer may choose perennial or food crop. The decision by a farmer to engage in the production of perennial crops is potentially endogenous of which there is the need to account and cater for this endogeneity as it may lead to inconsistent and bias estimates.

Likewise the livelihood diversification index is also perceived to be endogenous. The suspected endogeneity of livelihood diversifications may be as a result of the voluntary nature of a farmer to diversify his livelihood activities. For instance, some farmers might decide to crop diversify their livelihood because they are privy to certain characteristics that can easily support livelihood diversification than others, in terms of the benefit that diversification brings to the farmer. This type of selection bias if not accounted for, may overstate or understate the actual effect of livelihood diversification on household dietary diversity score (food security) in the regression models specified in equation (3.23). On the other hand, farmers may fail to practice livelihood diversification because they are not privy to vital information on the benefit of diversifying into other livelihood activities or they lack certain characteristics that may support diversification. In such instance, when we fail to control for the potential endogeniety, the real benefits that comes with engaging in livelihood diversification may be underestimated.

If the model is estimated without accounting for this endogeneity, the estimates would be biased and inconsistent which could result in wrong interpretation and policy implication.

3.6 Measurement of Dependent Variables

Household consumption expenditure per capita

Household consumption expenditure per capita: According to the GLSS (2010), household consumption expenditure is the expenditure for private consumption on goods and services during the reference period. This comprises all expenses in cash or credit by members of households on goods and services for personal use (including taxes paid for goods and services). In addition, all goods, services and facilities received in kind, either free or concession. According to Darity and Goldsmith (1996), household consumption expenditure pattern changes in line with the changing in times. In order to meet the needed expenses, money or income shall be dealt with as soon as possible. This is because the change in time has become one of the factors that influence the pattern of household consumption indirectly, as the change currently affects the cost to acquire goods and services, due to inflation that prevails in a country. Within the context of this study, consumption expenditure per capita was computed by dividing total consumption for each data unit by its respective total household size.

Household income per capita: Per capita income (PCI) or average income is the measure of average income earned per person in a given area within a specified period of time. Per capita income in this study is calculated by dividing the total annual income earned by each respondent by their respective total household size. Per capita income can be used to evaluate the average per person income for an area and to evaluate the standard of living and quality of life of the population (Will, 2019).

Household dietary diversity score: The study quantitatively examined farmers' food consumption by estimating the number of eating occasions to understand their dietary diversity over a period (the past seven days). Dietary diversity proxy measure of household food security was used. A 7-day household eating frequency of diversified food groups (Kennedy *et al*., 2010) was used to compute the mean dietary diversity score. The study represents it as HDDS. It is a self-reported score on eating habits calculated by summing over the frequency of eating of 12 food groups over the past 7 days and dividing it by 12 to arrive at the mean HDDS. The score of the HDDS ranges from 0-12 with categorization in to high (6-12), medium (4-5) and low (0-3) in terms of food security (FAO, 2013). After computing the mean HDDS, it was used as a dependent variable for estimating the impact of perennial crop production on food security. These food groups included in the computation of the HDDS indicator where: Cereals; Root and tubers; Vegetables; Fruits; Meat, poultry, offal; Eggs; Fish and seafood; Pulses/legumes/nuts; Milk and milk products; Oil/fats; Sugar/honey and Miscellaneous.

Livelihood diversification index: This study developed the econometric model to estimate the perennial crop production on livelihood diversification strategies of perennial crop farmers'. As result, the extent of perennial crop farmers' livelihood diversification is measured by the Inverse Herfindahl–Hirschman Diversity *(IHHD)* index using the formula:

$$IHHD = \left[1 \big/ \sum Y_j^2 \right] i \qquad [3.12]$$

Where Y_j represents the proportional contribution of each livelihood activity j to farmer i's overall income. Farm livelihood activity consists of three broad categories of farm household income sources, namely: on-farm (perennial crops, annual crops and livestock), off-farm (trading and others) and non-farm (wage and employment) practices (Ellis, 2000; Ellis & Freeman, 2004), that indicate the maximum value of the IHHD index is limited to be three. In this model, all sampled farmers or farm households are assumed to be engaged in at least one farm activity, on-farm activities, which mainly may include the production of perennial and/or annual crops and livestock. Thus, the IHHD lies between one and three.

Table 3.1 presents the description and measurement of dependent variables to be measured across the three objectives of the study.

Table 3.1: Summary of Description and Measurement of Dependent Variables

Dependent Variable	***Definition***	***Measurement***	***Apriori expectation***
Production of Perennial crops			
Cashew	cashew production	Continuous	+
Mango	mango production	Continuous	+
Welfare Indices			
Consumption Expenditure per capita	expenditure per capita of farmer household	Continuous	+
Income per capita	Income per capita of farmer household	Continuous	+
Food Security			
Perennial crop	production of perennial crops	1, perennial: 0, annual	+/-
HHD	Household dietary diversity score	Continuous	+
Livelihood Diversification	number of economic activities engaged in	Continuous	+

3.7 Measurement of Independent Variables

3.7.1 Farmer demographic characteristics

Sex variable measures the effect of sex on perennial crop production. It is a dummy indicating 1 if the farmer is male and 0 otherwise. The anticipated sign of the coefficient of sex is however indeterminate because of the argument that; men and women farmers are both efficient in resource use (Uwajumogu, 2019).

Age in years is used as a proxy for farming experience in most empirical studies. Since, farming experience increases with increase in age, it is expected that the age of the farmer would have a positive effect on perennial crop production. This is the case even though older farmers could be more traditional and conservative and hence show less willingness to adopt new practices **(**Sulemana**,** 2014**)**

Another variable that is hypothesized to influence the dependent variables of this study is *marital status*. It a categorical variable that assumes the values; 0 if a farmer never got married, 1 if a farmer is married, 2 if a farmer is divorced and 3 if a farmer is widowed. It expected to have mix effect on the crop production s any of these categories could either serve as a complement or reduction to output.

Household size refers to the number of people (adult men and women and children) who were living with the farmer during the 2019 cropping year. The expected sign for household size is mixed. A positive sign indicates that the larger the household size, the greater the impact on perennial crop production. A reason for a positive sign is allocation of financial resources to family members for their education and health (Mariano, 2012). On the other hand, larger household size might benefit from being able to use labour resources at the right time (Grabowski, 2014)

Education variable was measured as the number of years of schooling of a farmer. It represents the managerial ability of the farmer. Education as a human capital variable is a relevant factor in technology adoption. Educated farmers easily adopt improved farming technology and therefore should have higher probability of cultivating perennial crops than farmers with low level of education. The expected sign for education is positive.

Settlement in years measures the number years a farmer stays in the farming community. This is applicable to both farmers who are natives and non-natives of the farming community under study. This is expected to have a mix impact on the production of perennial crops.

Experience in crop production: This measures the number of years a farmer has been engaged in annual crop production. Experience is expecting to increase crop productivity because it makes farmers more aware of varied and best practices to adopt to increase crop productivity.

Household assets such as family labour, farm and non-farm income, agricultural farm land size, the value of farm machineries, among others, are also hypothesized to influence the choice of crops, diversification and food security.

Family labour: It is measured as the number of people from the family that are engaged in working in the farm from land preparation through to harvesting. The use of household labour on perennial crop or annual crop cultivation will increase productivity. Other studies observed that this will help the farmer minimize cost of hiring a labour during the production season, hence giving the farmer an opportunity to adopt new and better agronomic practices with less cost (Muzari, 2012). This would then have a positive impact on perennial crop production.

Farm size: This is the area of land in acres allocated to perennial crop cultivation. Whereas Deressa et.al (2010) postulate that wealthier farmers are more likely to have larger farm holdings and they can depend on their investments for survival. Gbetibouo (2009) also indicates that large farmers are more likely to adopt adaptation strategies since they have the capital and resources to do so. Farm size is expected to have an increasing effect on perennial crop production.

Income from perennial crop production: This refers to the income earned from the proceeds of perennial crop. It expected to have a positive impact on perennial crop production because, the income to could be re-invested in to the perennial crop farm to enhance productivity.

Non-farm activity: Non-farm activity measures other economic activities that the farmer engages him/herself in aside farming in general. This is a dummy variable denoting 1 if a farmer engages in any off-farm activity and 0 otherwise. The impact of off-farm activity on perennial crop production is expected to be mixed. While Abdulai and Hoffman,(2000) observed that, off-farm labour reduces productivity, while other argue that additional income generated by other household members through off-farm work, can cushion cost of reduction in labour supply (Ifeoma, 2014).

Total asset value: Asset value measures the total assets of farmers in monetary terms. Previous studies have indicated that farm household assets have significant effects on the adoption of agricultural technology (Mmbando and Baiyegunhi 2016). Danso-Abbeam and Baiyegunhi (2019) supports these previous studies as the value of farm asset indicates a positive and significant influence on fertilizer adoption.

3.7.3 Farm-specific characteristics

Distance of farm from home: Distance from farm to home is a measured of the kilometers a farmer travels to arrive at his farm. Farms that are relatively far from farming communities are more secured from the negative activities of man and domestic animals that impede productivity. Distance of farm from home is expected to have mix impact on the production of perennial crops.

Distance to market: The distance a farmer travels in kilometers from farm to the nearest market center to sell his farm produce. Distance from farm to the nearest market center is expected to have a direct impact on the cost a farmer incurs on transportation of his farm produce to the market to sell. This can impact negatively or positively perennial crop production.

Age of farm: The number of years a perennial crop farm has been established. Age of farm is critical measuring perennial crop production because, farms once established becomes a plantation over a relatively longer period of time. This could also be used in some cases as a proxy to experience in farming and managing perennial crop farm. It is expected to have a positive impact on perennial crop production

3.7.4 Institutional/Policy variables

Access to agricultural credit: Access to credit captures the effect of credit on perennial crop production. This variable is measured as a dummy; 1 if a farmer has access to credit and 0 if otherwise. Credit provides the means for many farmers to adjust their operation to keep up with the constant changes to improve their operations. It's often regarded as a major factor in agricultural production. Adegeye and Dittoh (1985) argued that "credit is the process of obtaining control over the use of money, goods and services in the present in exchange for a promise to repay at a future date". Availability and access to credit by farmers is often associated with increasing the probability of adoption of new strategies (Deressa, et.al, 2009). This will help farmers to be less vulnerable since they can adopt new strategies to curb the situation of climate extreme events even if it comes with cost.

Access to extension services: This is a dummy variable which measures farmers' access to extension services and otherwise. Generally, extension service helps in providing information about new agricultural innovation in Ghana. It serves as an important source of information on good agricultural practices as well as adaptation options for farming households.

FBO membership: Membership of Farmer-based Organization (FBO) is treated as a dummy variable with; 1 if a farmer belongs to an FBO and 0 otherwise. Simtowe, Asfaw, and Abate (2016) reported that social capital and network variables such as farmer-based organizations are important in explaining households' adoption decisions. This is because membership of farmers' groups may increase access to information on productivity-improving technologies, and serves as a leading force for positive adoption decisions.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter presents and discusses the results of the study. It describes the socio-demographic and economic characteristics of the farmers in the sampled districts of the Northern Region. The chapter answers the research questions which the study sets out to achieve in the order in which they were presented in Chapter One. First of all, it examines the determinants of choice of the type of perennial crops (cashew and mango). Secondly, it explores the impact of perennial crop production on the welfare of farmers using an impact analysis tool (PSM). Finally, it analyses the role of livelihood diversification on the impact of perennial crop production on food security using the CMP framework.

4.1 Descriptive and Inferential Statistics

The summary of the descriptive statistics of some selected farmer and farm characteristics are presented in Table 4.1 and Table 4.2. Table 4.1 describes the dependent variables whereas Table 4.2 discusses the characteristics of the explanatory variables.

4.1.1 Descriptive and inferential statistics of dependent variable

For this research, two different sets of respondents were considered, perennial and non-perennial crop farmers. The data revealed that perennial crop farmers were 215, which represented 55.6% as against 171 farmers, representing 45.4% of the sampled respondents. For perennial crop farmers, the data revealed that about 129 of the sampled farmers cultivated only cashew representing 60.3%. About 46 of the respondents cultivated mango exclusively, representing 21.3% while 39 farmers representing 18.2% cultivated both cashew and mango. The large proportion of farmers cultivating cashew could be attributed to the many projects about cashew that are being implemented in the northern region.

Figure 4.1 depicts the percentage share of the perennials crops across the sample farm households.

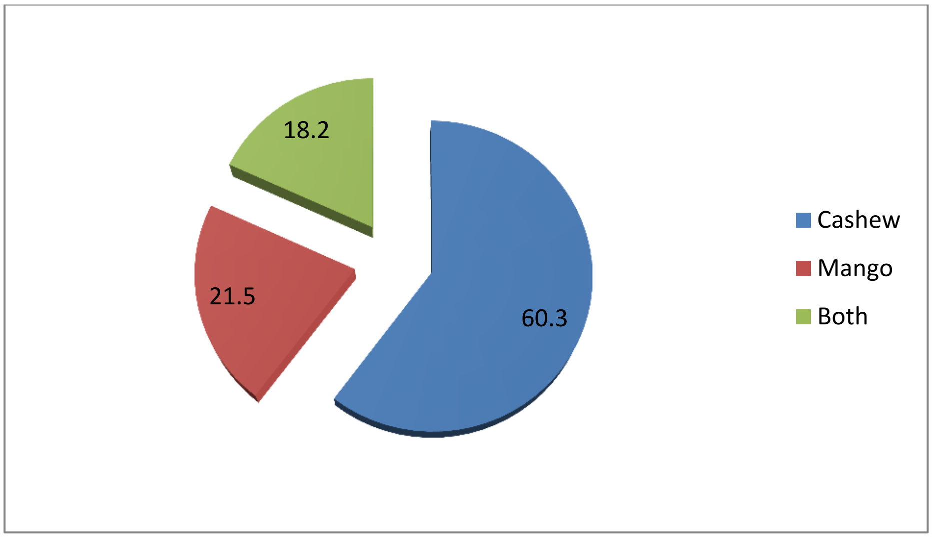


Figure 4.1: Distribution of perennial crop production across the sampled farm households

The annual income per capita earned by sampled farmers was also sought from the field. These incomes were earned either through perennial crops and/or annual crops and other non-farm and off-farm income as well as other economic activities apart from farming. It is essential to report that aside from perennial and annual crops production; some other economic activities were undertaken, which include livestock, petty trading, and salaried employment, among others. The result from Table.4.1 indicates that the average annual income per capita was GH¢ 1,264.89 for the full sample, and GH¢1669.24 and GH¢725.73 for the perennial and annual crop, respectively. The difference in the two samples is significant at 1% as indicated by the *t-values*.

Table 4.1: Inferential Statistics of Outcome Variables

Variable	***Full Sample***	***Perennial Crop***	***Annual Crop***	***t-test***
***Production of Perennial** Crops*				
Cashew	0.329	0.593		15.804[a]
Mango	0.119	0.215		6.845[a]
Both	0.101	0.182		6.175[a]
Outcome variables				
Consumption expenditure per capita	249.577	301.863	184.524	6.229[a]
Household income per capita	1264.894	1698.243	725.727	5.925[a]
Perennial crop	0.554	0.995	0.000	190.000[a]
HHDS (food security)	112.531	119.820	103.462	5.138[a]
Livelihood diversification	0.535	0.523	0.550	1.131

Source: Field Survey, 2019. [a], [b], denote significant level at 1%, and 5%

By implication, annual incomes distribution was more skewed toward perennial crop farmers as against annual crop farmers. Also, the results suggested that perennial crop farmers are relatively better-off with the average amount of monthly income, especially those that engaged in perennial and annual crops and other economic activities. The average annual expenditure per capita from the data is GH¢ 249.52 for the full sample, with a corresponding significant (1%) difference between the annual expenditure per capita for perennial and annual crop farmers. With livelihood Diversification, the mean value as revealed by the study is 0.54 for the full sample. There is however no significant differences between the treated (perennial) and the control (annual). This indicates that farmers in the study area depend on many economic activities for their sustenance. Regarding the household dietary diversity score (HDDS), which is treated as a proxy for food security in this study, 36% of the sampled household consumed six or more different food groups out of the 12 food groups defined by HDDS, and are thus, considered food secured. These are classified to be high in dietary diversity score. Also, 26% of households consumed between four to five food groups, while about 38% of the household were classified as low in dietary diversity since they consumed just about three or less of the food groups. There is also a significant difference in terms of the mean household dietary diversity score for the perennial and annual crop farmers, as indicated by the t-values. Table 4.2 depicts household dietary diversity score in the study area.

Table 4.2: Household Dietary Diversity in the Study Area

Dietary Diversity	***Percentage (%)***
1-3 (Low)	38
4-5 (medium)	26
6 or more (High)	36
Total	***100***

Source: Field Survey data, 2019

The welfare variables (income per capita and consumption expenditure per capita) indicate that perennial crop farmers (treated group) were better off than annual farmers (control group). Thus, t-values indicate a significant difference between the perennial crop producers and annual crop producers concerning the magnitude of the welfare indicators. Nevertheless, these descriptive statistics are limited regarding their implications for causality, as they fail to quantify and account for differences in observed characteristics between perennial and annual crop farmers.

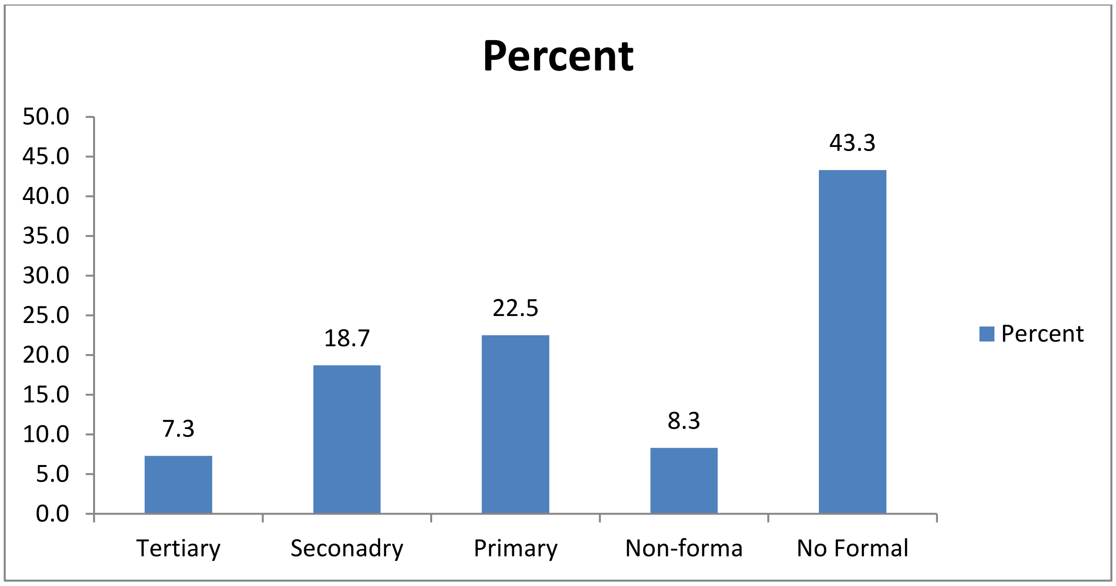
4.1.2 Descriptive and inferential statistics of independent variables

4.1.2.1 Demographic characteristics

From the data obtained, about 345 respondents were male-headed households representing 89.4 percent of the total sample whiles the remaining 41 were female-headed households representing 10.6 percent of the sample. This implies that the males are dominant in agricultural production, particularly the production of the crops under consideration, though there is no significant between the producers of annual and perennial crops. With respect to the age of the respondents, the data revealed an average age of 47 years with a standard deviation of 11 years. This suggests that respondents were mainly within the active labor force brackets. They could themselves farm with little or no technical assistance or support, provided they have all or most of the resources they need to do so at their disposal. As regards to the marital status of the respondents, the survey revealed that 287 farmers representing 74.4 per cent of the respondents were married as against 99 farmers who represented 25.6 per cent remained single either by dint of; not married, widowed, divorced or separated. Regarding the household composition, the average household size measured in terms of the average number of people within the household was 11 persons (full sample) with a standard deviation of 5 and a maximum of 36 persons. Also, the average number of those within the active labour (household labour) stood at 7 persons (full sample) with a standard deviation of 3, and also with a maximum of 21. This signifies that respondents (farmers') have enough family labor to be engaged in the various activities along the farming value chain from production through to processing and selling.

The survey also revealed the educational status of respondents both in terms of completed years and the level of completion. The mean number of completed years in education was 5.7 and a standard deviation of 5, which implies that majority of those who attended school, obtained only primary education with just a few obtaining secondary education. The bar chart presented in Figure 4.2 further expounds on the educational level of the respondents.

Figure 4.2: A Bar chart Showing Educational Level of Farmers



Source: Field survey (2019)

There were generally low levels of education among the farmers interviewed across the sampled districts, and Figure 4.1 depicts that. Whiles 43.3 percent of the respondents had no formal education, only 18.7 percent completed both Junior High Schools (JHS) and Senior High schools (SHS). Also, 22 percent of the farmers had primary education, and 8.3 percent and 7.3 of them had access to non-formal and tertiary education, respectively. These results revealed the low levels of interest on the part of persons living in the sampled communities to seek knowledge by acquiring both formal and non-formal education.

Table 4.3 Inferential Statistics of Independent Variables

Variable	***Full Sample***	***Perennial Crop***	***Annual Crop***	***t-test***
Demographic characteristics				
Sex of Respondent	0.894 (0.333)	0.902 (0.219)	0.884 (0.251)	0.574
Age of respondent	47.687(1.279)	48.383(0.907)	46.820(0.891)	1.309
Marital status	1.104(0.717)	1.164(0.593)	1.029(0.353)	1.962[c]
household size	11.228(0.517)	10.949(0.369)	11.576(0.355)	1.174
Number of years in education	5.010(0.289)	4.841(0.378)	5.221(0.445)	0.654
Settlement in years	3.008(0.879)	4.140(0.745)	1.599(0.398)	2.842[b]
Household labour	7.531(0.184)	7.098(0.268)	8.070(0.269)	2.494[b]
Farm-specific characteristics				
Distance of farm from home	4.228(0.149)	4.874(0.209)	3.424(0.210)	4.329[a]
Distance of farm from market	10.984(0.277)	11.818(0.415)	9.948(0.342)	3.395[a]
Acres of perennial crop	6.339(0.344)	11.434(0.528)		4.789[a]
Age of farm (perennial crop)	7.699(0.463)	13.888(0.542)		24.854[a]
Institutional variables				
Credit access	0.161(0.018)	0.252(0.029)	0.047(0.017)	5.685[a]
Extension access	0.580(0.026)	0.523(0.037)	0.651(0.038)	2.543[b]
FBO	0.187(0.019)	0.257(0.030)	0.099(0.024)	4.038[a]
Off-farm activity	0.052(0.012)	0.065(0.019)	0.035(0.015)	1.345
Non-farm Income	271.917(32.264)	309.860(29.171)	224.709(60.641)	0.780
Asset value	3250.060(148.50)	3391.136(168.43)	3074.535(250.708)	0.505
experience on annual crop	24.244(0.639)	25.154(0.939)	23.110(0.884)	1.606[c]
number of extension visits	1.236(0.064)	1.140(0.092)	1.355(0.086)	1.739[c]
household income from perennial crop	4471.580(258.093)	8065.561(387.364)		9.967[a]

Source: Field Survey, 2019. [a], [b], denote significant level at 1%, and 5% . Standard deviations are in brackets.

Though education indeed is a significant parameter in this study, it does not only influence but also guides through access to information on inputs, credit market, among others. Education makes access to information and the usage of such information easier. Hence, the low levels of farmers' education have an implication on their welfare and that of their households.

4.1.2.2 Farm specific characteristics

In terms of distance to the nearest market where some of them sell their perennial and annual crop produce, 11km was revealed as the average distance signifying that farmers could spend a relatively large amount of money on transportation. Also, the mean distance revealed by the study from home to farm was 4.23km, with a respective corresponding minimum and maximum distance from home to the farm being 0.5km and 21km respectively. This indicates that farm fields were relatively closer to farming communities. The study also revealed the average acres of perennial crop farm to 11.4acres and the average age of perennial crop farm to be 13.4 years.

4.1.2.3 Institutional variables

The results from the field indicate that on the average 16 percent and 58 percent of the respondents had access to credit and extension services respectively from the full sample, signifying a low participation in the financial services market. Specifically, credit was taken from sources such as Banks, microfinance institutions and family and friends. The results show an average amount of loan to be GH₵866. There is, however, significant difference in access to credit between perennial and annual crop farmers. This is indicated by the 1% significant level of the t-value. For access to extension services, a significant difference is again observed between perennial and annual crop farmers access to extension services. Also, the average number of times respondents accessed extension service was 1.24 times (full sample) with a minimum and maximum visits of 0 and 6, respectively. Also, 18.7% from the pooled sample of respondents belonged to the farmer-based organizations (FBO). The statistics also showed at significant levels that FBO membership is more dominant among perennial crop farmers than annual crop farmers. The data also revealed respondents to be very experienced in both perennial and annual crop farming. On average, a farmer has 9 years of experience in farming perennial crop with the minimum experienced farmer having only 1 year of experience, and the maximum having 40 years. However, for annual crops, the average experience as revealed by the data is 24 years, with a minimum experience of 1 year and a maximum of 70 years. Experience improves knowledge, and skill of labour and hence the vast experience earned by the farmer (either for perennial/annual crop farmer) are expected to translate into good yield and welfare of the farmers' households. The average proportion of household income from the production of perennial crop is GH¢8,065.56.

4.2 Determinants of Choice of Perennial Crop (Bivariate Probit)

Table 4.4 reported the results of bivariate probit estimation of the determinants of choice of types of perennial crops in the Northern region. The Wald test $(\chi^2(18) = 29.71, \rho = 0.000))$ is significant at 1% level of probability. This indicates that the hypothesis that all regression coefficients in each equation are jointly equal to zero is rejected. Also, the $rho(-0.72)$ indicate a strong negative correlation between the two crops (cashew and mango) under study. This, therefore, rejects the hypothesis that the two crops are not complements, and as such, confirms the substitutability of cashew and mango in the study area.

In the model, the explanatory variables are famer characteristics, farm-specific characteristics, and institutional factors. Some of the explanatory variables have significant effects on the two crops, while others significantly influence the production of either mango or cashew. The number of years a farmer had lived in the study area is positive and significant for cashew production. However, it has negative and significant effect on mango production. The positive and negative relationship indicates that farmers with a high number of years in terms of settlements in the farming community were more likely to farm cashew but less likely to farm mango, respectively. This may be because settlers who were farming in the rural communities of the study area had a direct or indirect firsthand experience in cashew production or were part of early adopters of the various cashew projects enrolled in the study area as indicated in Chapter two of this study.

The coefficient of household size was positive and statistically significant to the cultivation of mango and negatively associated with the production of cashew at 5% and 1% level of significance, respectively. Larger family sizes were more likely to cultivate mango and less likely to cultivate cashew. Family size plays an essential role for the production of any particular farm Produce.

Membership of FBO is negative and statistically significant for cashew production but positive and statistically significant for mango production, both at 1% levels of significance. This indicates that members of FBO are less likely to influence cashew production but are more likely to influence mango production. This confirms findings from the field that mango producers were more organized into farmers groups on mango production than cashew producers. Also, projects that enrolled these two crops in the Northern region, especially with mango

Table 4.4: Bivariate Estimation on Choice of Perennial Crop

Variable	***Coef.***	***Std. Err.***	***Coef.***	***Std. Err.***
	Cashew only		*Mango only*	
Settlement in years	0.015[c]	0.008	-0.023[c]	0.014
Sex of respondent	0.376	0.25	0.346	0.423
Age of respondent	0.011	0.008	-0.024[b]	0.01
Household Size	0.107[a]	0.021	0.049[b]	0.021
Annual Income	0.000	0.000	0.000	0.000
Credit access	0.177	0.229	-0.003	0.254
Farm distance from home	0.034[c]	0.027	0.032	0.031
Farm distance from market	0.026	0.016	-0.033	0.021
Access to extension service	0.116	0.164	0.559[b]	0.225
FBO	-0.687[a]	0.233	0.668[a]	0.22
Years spent in school	-0.028[c]	0.016	0.03[c]	0.017
Proportion of income from perennial crop	0.000[b]	0.000	0.000	0.000
Age of perennial crop farm	0.055[a]	0.009	0.043[a]	0.011
Constant	0.278	0.417	-1.898[a]	0.605
Number of obs = 386				
Wald chi2(22)=	118.01			
Prob > chi2 = 0.000				

Source: Field Survey, 2019. [a], [b], denote significant level at 1%, and 5%

production, dealt with farmers in the form of organized groups' more than cashew-based projects.

The coefficient of education level (number of years spent in school) was negative and statistically significant with cashew production and positively related to mango production at 10% level of significance. The unexpected sign for cashew production could be because the education level has been recognized to play an active role in the practice of agricultural technologies and crop production. Perennial crop farmers with a high level of education were more likely to cultivate mango and less likely to cultivate cashew. The finding is similar to Van Mele, Cuc and Van Huis (2001) who argued that education is a crucial element for agricultural technology and crop practice by smallholder farmers.

Age of farm was statistically significant for both cashew and mango production at 1% level of significance. This means an increase in the age of farm is more likely to fuel both cashew and mango production. This was evident from the field that farmers with relatively older cashew and mango plantations did invest in establishing new farms.

The distance of farm from home and the proportion of household income were the explanatory variables that were statistically significant for only cashew production. An increase in distance in kilometers from home to farm was more likely to increase cashew production by 0.034 at 10% level of significance. The contribution of cashew production to household income positively and significantly (5%) affect cashew production. This indicates an increase in the proportion of income from cashew is more likely to increase cashew production.

Age of farmer and access to extension services are also the explanatory variables that only affects mango production in the study. A one year increase in age is more likely to increase cashew and mango production both at 1% level of significance. This suggests that older farmers do more of cashew and mango production as compared to other crops. Access to agricultural extension services was significant and positively related to mango production at 5% level of significance. Mango farmers with access to extension services were more likely to increase mango production. This result indicates that extension agents play a vital role in transferring good agronomic practices in mango production, advising and informing at the farmer's levels. They train farmers and strengthen their skill through training on good agricultural practices. This is in tandem with Pratt and Wingenbach (2016) in the practice of green manure and cover crops technology in Uruguay but inconsistent with Rahman and Chima (2015).

4.3 Determinants of Perennial Crop Production (Logit Model)

In the works of Danso-Abeam and Baiyegunhi, (2019), Appiah, (2016), Wosen et.al, (2017), Kassie, Sheferaw and Muricho, (2011) and Denkyirah et.al, (2016), the conditional probability of any programme or activity can be predetermined using predicted values from a standard logit model to predict the propensity scores of adopters and non-adopters in a given sample. As a result, the outcome of the determinants of perennial crop production is presented in Table 4.4.

The logit model is statistically significant at 1% as indicated by the *LR* (*chi square (11), p=0.000)*. This suggests that the model fits the data well. Marginal effects are also estimated by the study which was used to interpret the results since the coefficient parameters do not provide any meaningful interpretations regarding the magnitudes in probability models. The results in Table 4.4 indicate that aged farmers are more likely to engage in perennial crop production at 5% level of significance. Thus, a year increase in the age of the respondents increases their probability of cultivating perennial crops by 0.8%. Household size is significant and positively

Table 4.5 Estimates of the logit regression model of the determinants of

Variables	*Coefficient*	*Marginal effect*
Sex of Respondent	0.3072 (0.2576)	0.001 (0.102)
Age of Respondent	0.0166[b](0.0079)	0.008[b](0.003)
Household Size	0.0755[b](0.0366)	0.020[b](0.014)
Household Labour	0.2544[a](0.0538)	-0.093[a](0.020)
Annual Income	0.0001[a](0.0000)	1.000[a](0.000)
Credit Access	1.0281[a](0.2558)	0.331[a](0.057)
Farm Distance from Home	0.1245[a](0.0273)	0.048[a](0.010)
FBO Membership	0.6821[a](0.2137)	0.219[a](0.062)
Years in School	0.0280[c](0.0148)	-0.014[a](0.006)
Non-Farm Income	0.0002[b](0.0002)	0.000[b](0.000)
log of Asset Value	0.1951(0.0639)	-0.107(0.024)
Constant	0.2599[a](0.4991)	
Summary Statistics:		
Number of obs	386	
LR chi2(11)	146.54	
Prob > chi2	0.000	
Pseudo R2	0.2762	

Source: Field Survey, 2019. [a], [b], *denote significant level at 1%, and 5% and standard errors in perenthesis*

Influence perennial crop production. This indicates that larger households are more likely to increase perennial crop production than smaller households. The results also indicated that increasing the size of the households by a person increases the propensity of perennial crop production by about 2%. The results also indicated that household labour had a significant but negative impaction on perennial crop production 9.3%. This show perennial crop farmers use more of hired labour than household labour. The annual income of farmers has a positive and significant bearing on the production of perennial crops, even though the magnitude is not substantial. This indicates that farmers with higher annual incomes are more likely to diversify their income into perennial crop production.

In line with Kassie et al. (2015), farmers who accessed agricultural credit in the form of inputs or cash have a higher likelihood of cultivating perennial crop compared to those who did not. The distance covered by the farmer to the farm positively influenced perennial crop production and was significant at the 5 percent level. This implies that the further away the farm is from the main road, the more likely the farmer will produce perennial crops. This could be because farms far away from the communities of resident are easy to get, and do not get invaded by animals and other human activities. A percentage increase in the distance from home to farm would increase the likelihood of cultivating perennial crops by 4.8%.

Similarly, membership of farmer-based organizations (FBO) has the probability of increasing perennial crop production by 21.9%. Simtowe, Asfaw, and Abate (2016) observed that social capital and network variables such as FBOs are essential in explaining households' adoption decisions. This stems from the fact that membership of farmers' groups may increase access to information on productivity-enhancing technologies, and serves as a driving force for positive adoption decisions. The level of education of the farmer (measured as years spent in school) has a negative influence on the farmer's likelihood to cultivate perennial crops but was significant at the 10 percent level. Results show that an increase in years of education by one year is less likely to influence the production of perennial crops by 2.5%. The negative influence may be because more educated farmers diversified their income into other economic activities. The non-farm incomes positively and significantly influenced the likelihood of cultivating perennial crop. A percent increase in non-farm incomes of a farmer has the probability of increasing the production of perennial crops by 0.02%. This finding suggests that farmer's financial endowment increases the probability of engaging in perennial crop production. Previous studies have indicated that farm household assets have significant effects on the adoption of agricultural technology (Mmbando and Baiyegunhi 2016). This study contradicts these preceding studies as the value of farm assets indicates a negative and significant influence on perennial crop production.

4.4 Impact of perennial crop production on households' welfare

In estimating the impact of perennial crop production on the treated groups with the PSM, the study performed some diagnostic tests to examine the quality of the matching process after predicting the propensity for both perennial and annual crop farmers. Figure 4.3 provides a density distribution of propensity score for perennial crop producers and annual crops farmers, showing that there is a considerable overlap of distribution for both the perennial and annual crop farmers. Thus, the common support condition is satisfied. The upper and bottom sections of the histogram indicate the propensity score distribution of the perennial and annual crop producers, respectively. The distribution densities of the score are indicated on the vertical axis. Nevertheless, the reliability of the common support condition depends on the extent to which the matching techniques can construct a resemblance between the treated and the control group conditioned on the covariates (Danso-Abbeam, 2019).

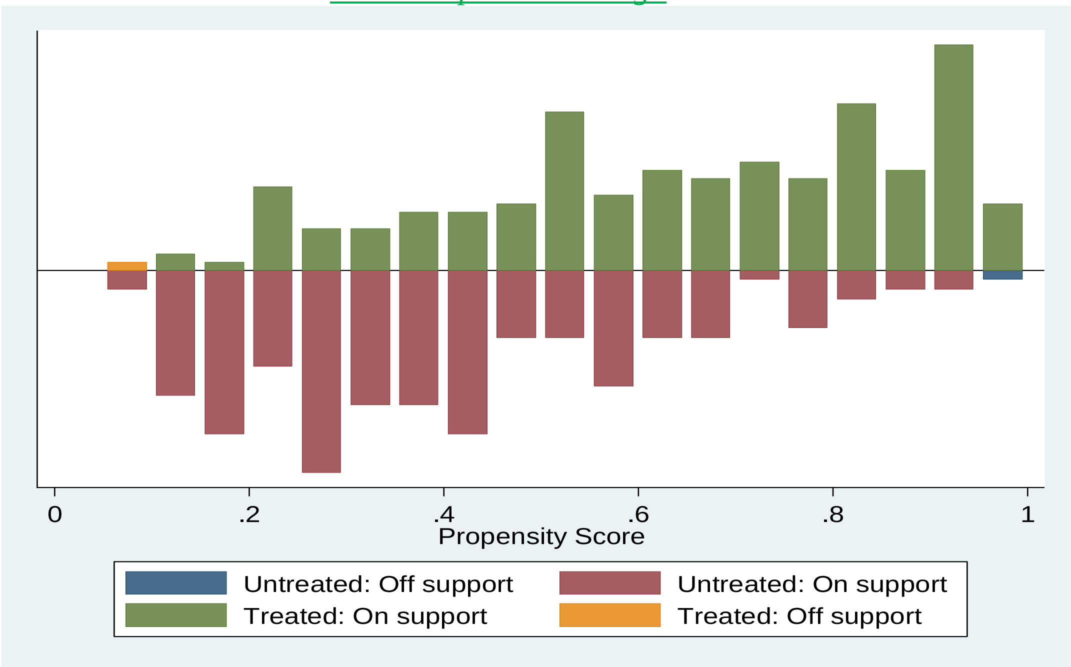


Figure 4.3 provides a density distribution of propensity score

Notes: "Treated: on support" indicates perennial crop farmers have a suitable comparison group (annual crop farmers). "Treated: off-support" indicate the perennial crop producers that did not have a suitable comparison group (annual crop farmers).

Another indicator to confirm the quality of the matching technique is the mean standardized test before and after matching (Rubin, 1974). Table 4.7 presents the matching quality of the combined covariates.

The standardized mean difference for the overall covariates reduces from 15.2% before matching to about 4.4% after matching, resulting in a total bias reduction of about 71%. This result confirms the statistical validity of the comparison as the mean standardized value is less than 5% after matching (Rosenbaum and Rubin 1983). Moreover, as indicated by the p-values of the likelihood ratio tests (LR), the joint significance was not rejected before matching (p-value = .000) but was rejected after matching (p-value = .151). The Pseudo R^2 also reduced considerably after matching. The high total bias reduction, low mean standard bias, low pseudo R^2 and the insignificant p-value of the LR after matching is an indication that the propensity score technique is relatively successful and can be used to assess the impact of perennial crop farm households with similar observed characteristics.

Table 4.6: Test of equality of means of each variable before and after matching

Variable	*Unmatched Sample*			*Matched Sample*			
	Perennial	*Annual*	*p-values*	*Perennial*	*Annual*	*p-values*	*%reduction bias*
HHDS	115.94	103.85	0.00[a]	116.24	106.41	0.00[a]	18.7
Sex of respondent	0.90	0.88	0.64	0.90	0.83	0.05[b]	-346.5
Age of respondent	47.13	46.01	0.38	47.20	45.18	0.10[c]	-80.1
Household size	10.53	11.32	0.13	10.52	10.25	0.56	65.3
Household labour	6.85	7.78	0.01[a]	6.83	6.56	0.42	71.6
Annual income	12521.00	8919.00	0.00[a]	12573.00	9535.10	0.00[a]	15.7
Access to credit	0.19	0.05	0.00[a]	0.19	0.28	0.04[b]	35.6
Distance of farm from home	4.34	3.50	0.01[a]	4.34	4.08	0.39	68.3
Belonging to an FBO	0.21	0.10	0.01[a]	0.21	0.33	0.01[a]	-7.8
Completed years of education	4.49	5.06	0.33	4.52	4.26	0.64	53.5

Source: Field Survey, 2019. [a], [b], *denote significant level at 1%, and 5%*

Table 4.7: Summary of the equality indicators before and after matching

Sample	*R^2*	*LR Chi^2*	*$p>Chi^2$*	*Mean Bias*	*Total % in Bias Reduction*
Unmatched	0.276	64.54	0.000[a]	15.2	
Matched	0.038	19.61	0.151	4.4	72.15

Source: Field Survey, 2019. [a] *(1% level of significance)*

Table 4.8 presents the result of the estimates of the average impact of perennial crop production on the welfare of the treated farm households using three different matching algorithms: nearest-neighbour, kernel-based and radius matching. The three techniques were used to check the robustness of the results. The estimated results confirm that perennial crop production has a positive and significant impact on the welfare of the farmers in Northern Ghana. The estimated impact on consumption expenditure varies from GH¢104.611 to about GH¢105.153 depending on the estimation technique. Thus, perennial crop producers expend between GH¢104.611 and GH¢105.153 more compared to annual crop producers.

Table 4.8: Impact of perennial crop production on the farmers' welfare

Outcome Variable	***Nearest Neighbor***	***Kernel Matching***	***Radius Matching***
	ATT	***ATT***	***ATT***
Expenditure per capita	104.61[a] (24.07)	104.86[a] (23.98)	105.15[a] (22.83)
Household income per capita	307.43[a](108.25)	300.64[a] (106.13)	307.77[a] (102.67)

Notes: ATT is the average treatment effect on the treated. The standard errors reported in the parentheses with [a, b, c] indicate significant levels at 1%, 5% and 10%, respectively.

For household income per capita, the estimated impact is in the range of GH¢ 300.644 and GH¢ 307.784, indicating that perennial crop farmers get more income per capita as compared to annual crop farmers. This finding is in tandem with the studies of the World Bank group (World Bank, 2016) in their policy research paper on the prevalence, economic contribution, and determinants of trees on farms across Sub-Saharan Africa. In this study, real per capita consumption levels (2011 PPP) tree growing households and non-tree growing households was compared. After controlling for district level effects, the study found out that tree cash crop growers were on average substantially better off.

4.5.1 Sensitivity of ATT estimates to hidden biases

One of the significant shortfalls in PSM is that selection into treatment is based on observed covariates. Caliendo and Kopeinig (2008) noted that matching estimators are not robust to hidden bias due to unobserved variables. The study, therefore, checks the robustness of the estimates obtained from PSM to depart from the strong assumption of CIA using the bounding technique suggested by Rosenbaum (2002).

Table 4.9: Robustness of the ATT estimates to unobserved heterogeneity using bounds test.

Gamma	*Sig+*	*sig-*	*t-hat+*	*t-hat-*	*CI+*	*CI-*
1	0	0.1585	-0.0363	-0.0363	-0.1075	36867.00
1.1	0	0.3318	-0.0560	-0.0163	-0.1300	0.0588
1.2	0	0.5321	-0.0737	0.0031	-0.1493	0.0784
1.3	0	0.8401	-0.0913	0.0209	-0.1678	0.0784
1.4	0	0.8401	-0.1089	0.0377	-0.1841	0.1130
1.5	0	0.9201	-0.1247	0.0534	-0.1990	0.1297
1.6	0	0.9634	-0.1384	0.0672	-0.2151	0.1445
1.7	0	0.9844	-0.1513	0.0806	-0.2299	0.1591
1.8	0	0.9938	-0.1642	0.0923	-0.2438	0.1725
1.9	0	0.9977	-0.1753	0.1034	-0.2578	0.1860
2	0	0.9992	-0.1856	0.1148	-0.2699	0.1991
2.1	0	0.9997	-0.1955	0.1258	-0.2814	0.2114
2.2	0	0.9999	-0.2056	0.1364	-0.2927	0.2226
2.3	0	1	-0.2265	0.1457	-0.3035	0.2328
2.4	0	1	-0.2265	0.1553	-0.3132	0.2428
2.5	0	1	-0.2351	0.1651	-0.3234	0.2533
2.6	0	1	-0.2441	0.1729	-0.3234	0.2627
2.7	2E-13	1	-0.2531	0.1819	-0.3424	0.2712
2.8	3E-14	1	-0.2691	0.1898	-0.3504	0.2795
2.9	4E-15	1	-0.2760	0.1983	-0.3583	0.2877
3	6E-16	1	-0.2760	0.2055	-0.3661	0.2959
3.1	1E-16	1	-0.2829	0.2132	-0.3745	0.3045
3.2	0	1	-0.2897	0.2209	-0.3824	0.3116
3.3	0	1	-0.2967	0.2270	-0.3914	0.3204
3.4	0	1	-0.3035	0.2328	-0.3989	0.3280
3.5	0	1	-0.3093	0.2391	-0.4072	0.3364

Notes: gamma = log odds of differential assignment due to unobserved factors. sig+ = upper bound significance level sig− = lower bound significance level. t-hat+ = upper bound Hodges-Lehmann point estimate t-hat− = lower bound Hodges-Lehmann point estimate. CI+ = upper bound confidence interval (a = .95) CI− = lower bound confidence interval (a = .95).

This is to assess if the estimate based on matching is robust to a possible presence of some unobserved confounders. The result of the Rosenbaum bound (*rbounds*) test is reported in Table 4.9. The results indicate that ATT estimates are very robust to unobserved heterogeneity to the extent that even when the log odds of differential assignment to treatment is more than tripled (gamma = 3.5), the results are still robust to hidden biases. Hence, the result obtained from the PSM technique is free from hidden biases and the increase in welfare had come as a result of perennial crop production rather than differences in some unobserved factors.

4.5.2 Heterogeneity effects among perennial crop producers

The estimated ATT reported in Table 4.10 assumes no variation in the impact of perennial crop production for all farmers in the treatment group (adopters). However, there are differences in effects among treatment group because of differences in their socio-economic characteristics. The study analyses the existence of heterogeneity of the impact of perennial crop production across the various socio-economic and institutional variables using ordinary least square (OLS) techniques.

The finding from Table 4.10 suggests that welfare has a heterogeneous effect on perennial crop production. The estimated results show that all the explanatory variables with the exception of the household dietary diversity score are significant in influencing the welfare of perennial crop farmers. Perennial crop production, sex of respondent, age of respondent, household size, household labour, annual income, access to credit, distance of farm from home and membership in the farmer-based organization, were positive and statistically significant for welfare among perennial crop producers. This implies that perennial crop production increases welfare among male perennial crop farmers, farmers who are old, large household size and household labour, farmers who have access to credit, farms that are located far from home and farmers who are members of FBO.

Table 4.10: Heterogeneous impacts among perennial crop farmers

Variable	*Coefficient*	*Standard error*
HHDS	0.002	0.000
Sex of respondent	0.000 [a]	0.007
Age of respondent	0.006[a]	0.000
Household size	0.018[a]	0.001
Household Labour	0.002[a]	(51.240)
Annual income	0.000[a]	2.807
Credit access	0.313[a]	0.007
Distance of farm from home	0.041[a]	0.001
FBO	0.195[a]	0.006
Years spent in school	-0.012[a]	0.000
Constant	0.082[a]	0.013
N	351	
R^2	0.98	
F	12.89a	

Source: Field Survey, 2019. [a], [b], denote significant level at 1%, and 5%. The dependent variable is the consumption expenditure per capita (log transformed) of the treated group (perennial crop farmers).

Sex of respondent is significant 1% level, even though the magnitude is almost equaled zero. However, the positive coefficient implies that male produce perennial crop more than their female counterpart. This is because male farmers tend to own more vital production input, such as land and capital, than their female counterpart. This result is in line with (Kinkingninhoun-Mêdagbé *et al.*, 2015). Age of respondent has a positive (0.6%) and a significant effect on the welfare of perennial crop farmers at 1% level of significance. The positive effect of age on the welfare shows that as the age of perennial crop farmers increases, they gained more experience in their production environment both social and economic and that could translate positively to improving productivity, and subsequently their welfare. Household size also contributes significantly to the welfare of perennial crop farmers. It can be observed from the test results that an increase in household size leads to an increase in the welfare of perennial crop farmers at 1% level of significance. This implies that larger household size makes farmers of perennial crop more productive, which contributes positively to their welfare. Household labour, which is the number of active persons in the household, increases the welfare of perennial crop farmers by 0.2%. This further suggests that an increase in the household labour of perennial crop farmers leads to a corresponding increase in their welfare. As the active labour force is expected to contribute positively to the productivity of perennial crop production, which further leads to an increase in welfare.

The annual income of perennial crop farmers positively and significantly affects their welfare, even though the magnitude is almost equals zero. This implies that an increase in annual income leads to an increase in the productivity of perennial crop, which contributes significantly to their welfare. This could further attest to the fact that perennial crop farmers with increased incomes are in a better position to procure the required farm inputs and also adopt new technologies, which will eventually boost productivity.

Access to credit has a positive and significant influence on the welfare of perennial crop farmers. The estimated coefficient (0.313) of access to credit implies farmers who have access to credit are about 31.1% more productive than those who have no access to credit. This could further clarify the fact farmers who have access to credit can easily access farm inputs and cater for the cost of labour and other operational cost needed in the production of perennial crops. This finding is in line with the study of Tedesse (2015). Similarly, the distance of farm from home contributes significantly to improving the welfare of perennial crop farmers. The estimated result (0.041) from the test indicates that farms that are located far from the farmers' dwelling communities are 4.1% more productive than those located close to the communities. The plausible explanation is that farms that are located farther away from the nearby communities are free from destructions of human and animal activities.

Membership in the farmer-based organization is positive and significantly influences the welfare of perennial crop farmers. The estimated coefficient of FBO membership implies that perennial crop farmers who are members of FBO are about 19.5% more productive than those are not members of FBO. The possible explanation for this situation is that farmers that belong to FBOs get essential information about improved farm technologies, farm input subsidy, and have easy access to input and output markets than farmers who are non-FBO members with no membership in the farmer-based organization. This result is consistent with Baiyegunhi *et al.* (2019).

However, years spent in school by perennial crop farmers reduce their welfare. This implies that perennial crop farmers who are less educated in terms of the number years spent in school have a better welfare compared with those with high level of educational attainment. This could be attributed to the fact that the more a perennial crop farmer spent time in school, the more he is to open various income-generating activities. This makes them pay little or no attention to perennial crop production, which reduces productivity and subsequently, welfare.

4.6 Impact of Perennial Crop Production on Household Food Security and Livelihood Diversification

The result in Table 4.11 presents estimates from the CMP framework. The *antahrho* reported in the last three rows of the table is a measure of selection bias. The *atanhrho* values are all statistically significant at 1%, 1% and 10% respectively. This suggests that there is a correlation between the error terms of the three equations. The negative values of *atanhrho_12*, *antahrho_13* and *antahrho_23* show that there might be some omitted variables that affect both the outcome variables and perennial crop production negatively. A positive sign of *atanhrho* can be said in reverse. The results also indicate that the likelihood test ratio and its associated *p-value* strongly reject the null hypothesis of no endogeneity. This implies that individual estimation of the models would have probably led to biased estimates. Therefore, the CMP estimates are relatively more efficient and reliable. From the Table, model I, model II, and model III represent perennial crop production, livelihood diversification, and household food security, respectively. The following sub-sections discuss each of them.

Perennial crop production: Perennial crop production can be influenced by institutional, household and farm level-specific factors. Table 4.11 presents factors that determine perennial crop production. Five out of the six factors were significant in explaining the farmer's choice of perennial crop production. Farmers' access to credit exhibited a significant (1%) and positive influence on perennial crop production. This result is, however, inconsistent with that Abafita and Kim (2014) who found access to credit as well as remittances to have a negative influence on food security.

Table 4.11: CMP estimation of the impact of perennial crop production on food security and livelihood diversification

	CMP estimation					
Variables	***Model 1***		***Model 2***		***Model 3***	
	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E
Age of respondent	-0.004	0.006				
Access to credit	0.977[a]	0.241				
Distance of farm from house	0.088[a]	0.027				
FBO membership	0.718[a]	0.215	0.044	0.037	6.588	1.530
Annual Income (log)	0.531[a]	0.097				
Access to extension	-0.490[a]	0.153				
Perennial crop			15.742[b]	2.510		
Total asset value (log)					4.993[c]	1.172
Off-farm Income			-0.039		-0.030	0.028
Expenditure per capita			0.000[b]	0.000	0.050[b]	0.023
HHDS (Food security)					0.119[b]	0.064
Household size					0.101	0.374
Years Spent in school					0.623[c]	0.288
Sex of Household head			-0.163	0.104	-0.126	
Income per capita			0.000[b]	0.000		
Proportion of household income			0.000[c]	0.000	0.001[a]	0.000
Constant			0.668[a]	0.109	49.418[a]	9.000835
Parameters atanh /lnsig and sig						
atanhrho_12	-0.38[a]	0.164556				
atanhrho_13			-0.208[a]	0.12933		
atanhrho_23					0.067[c]	0.060251

Source: Field Survey, 2019. [a], [b], denote significant level at 1%, and 5%. Standard errors in parentheses.

There was a positive relationship between income earned annually and the production of perennial crops. The result implied that farmers who earn more income have a higher probability of cultivating perennial crops compared to annual crops. Distance covered by farmers to the farm was significant and positively influenced the production of perennial crops. This implies that farms that are located relatively far away from home are free from humans and animal invasion and theft. This finding is consistent with a prior expectation of a negative relationship and that of Berihun et al. (2014).

The positive effect of FBO on perennial crop production suggests that once farmers are organized into groups, the probability of being engaged by stakeholders in the perennial crop sector is very high. This will help boost their interest in terms of knowledge and market through capacity building, which will more likely translate to increasing perennial crop production. Another important observation was the negative and insignificant relationship between extension visits and perennial crop production. The finding highlights the fact that farmers who receive extension visits from MoFA extension agents tend to cultivate less of perennial crop introduced to them by government institutions, NGOs, research institutions and donor-supported projects.

Impact of perennial crop production on livelihood diversification: The second equation of the CMP model estimates the impact of perennial crop production on the livelihood diversification. The dependent variable (Livelihood Diversification) is continuous and the results are presented in equation 3 of Table 4.11

In-line with expectation, perennial crop production has a positive impact on livelihood diversification at 5% levels. This implies perennial crop farmers are more diversified in terms of livelihood activities, which have the tendency of increasing their income-generating activities. Expenditure per capita has a positive and significant influence on livelihood diversification at a 5% level of significance. This implies that an increase in expenditure per capita goes with an increase in engagement in more income-generating activities. Per capita income also has a positive and significant impact on household livelihood diversification, although, the magnitude is not substantial. This is an indication that increases in income influences the farmer households to venture into more income-generating activities, thus diversifying their source of livelihood. The proportion of household income that comes from the production of perennial crops has a significant and positive bearing on livelihood diversification. Increase in the proportion of household income that comes from the production of perennial crops increases livelihood diversification. This implies that farm households that engaged in perennial crop production are more flexible in venturing into other income-generating activities.

4.6.2 Impact of crop production on food security (HDDS)

The third and final equation of the CMP model estimates the impact of perennial crop production on household food security. The dependent variable (Dietary Diversity Score) is continuous. Study results in Table 4.8 indicate that of the five regressors under model 3, four of them were found statistically significant in influencing household food security. As expected, livelihood diversification has a positive impact on farmers' food security status. Thus, livelihood diversification increases household food security status by 0.11 and it is significant at 1%. This implies that farm households engaging in diverse livelihood activities are more food secured compared to their counterparts producing food crops such as maize, rice, wheat, among others. This finding is in tandem with the works of Toensmeier (2016), who observed that perennial crops help in addressing challenges to food insecurity, food injustice as well as environmental problems related to biodiversity.

The households' total asset value positively and significantly affects food security at 1% level of significance. Farmers' ability to pursue all these production activities is greatly influenced by their level of wealth measured by their wealth index. Cultivating perennial crops required activities and practices such as land preparation, planting, fertilizer application and composting and organic manure. All this involves not only the purchases of inputs but also the cost of acquiring, gathering, transporting and spreading compost and animal droppings on perennial farms. The study found asset value to be a highly significant and positive determinant of food security. That is, for every unit increase in farm household asset value, food security increases by 4.055.

However, the distance from farm to market is observed by the study to have a significant but negative impact on food security. The farther away the marker from the farm limits farmers' access to the market, which affects their farm incomes and consequently, their food security status. Expenditure per capita also has a positive and significant bearing with food security at 5 %. Thus, a unit (measured in Ghana cedi) increase in spending per capita makes farm household more food secured by 0.05 units.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Summary

This section of the report presents a summary of the findings, conclusions as well as policy recommendations.

This study has examined perennial crop production and its impacts on welfare, food security, and livelihood diversification. The study specifically examined the factors influencing the choice of types of perennial crop production. Under this study, particular importance was placed on factors that affect the production of both cashew and mango, and also, to test their complementarity or otherwise using the biavariate probit model. It also explored the effect of perennial crop production on farmers' welfare by comparing the welfare characteristics of perennial and annual crop producers through the propensity score approach, with income and expenditure per capita as welfare indicators. Finally, it examined the individual and combined effect of perennial crop production on food security and livelihood diversification of farm households under the CMP approach.

Findings from the study indicate that mango and cashew are substitutes. Also, the majority of perennial crop farmers (33%) are cashew farmers, while 12% of perennial crop farmers are mongo farmers. However, 10% of perennial crop farmers do both cashew and mango. This indicates that a significant proportion of perennial crop farmers are into cashew production. It was also observed from the field that farmers who do perennial crops also complement it with annual crops such as, maize, rice, soybeans beans, yam, vegetables among others to create additional source of income as well as food for the household. Among the expected factors influencing farmers' choices of type of perennial crop production, access to credit, the distance of farm from home and distance of farm from market has a positive and significant bearing on cashew production. On the contrary, household size, FBO membership, and years spent in school significantly reduce cashew production. With the determining factors for mango production, household size, access to extension services and FBO membership has a positive and significant effect on mango production, contrary to age of respondent which has a negative and significant impact on mango production.

On the impact of perennial crop production on the welfare of farmers, the study reveals that using expenditure and income per capita as indicators of welfare, perennial crop farmers earn and spend more as compared to annual crop farmers. This suggests farmers who in to perennial crop production earn more income relative to annual crop farmers, and as such are better off in terms of welfare. This is reflected in their expenditure as well. Also, access to credit, distance of farm from home, FBO membership and annual income positively and significantly affect perennial crop production. The number of extension visits, however, negatively and significantly affects perennial crop production.

With regards to the factors influencing farm household food security, the results shows that perennial crop production, total asset value expenditure per capita and distance of farm from market to be statistically significant. In the context of the determinants of livelihood diversification, household dietary diversity score (food security), per capita income and proportion of household income earned from the production of perennial crops were demonstrated to have significant influence.

5.2 Conclusions

Household size, FBO membership and number of years spent in school significantly reduce cashew production. This implies that cashew farmers do not draw on the services of household labour in cashew production. Even if they do, the majority of household labour goes to the production of annual staples since that is meant for direct consumption by the household. Also, there are no organized cashews FBOs among cashew farmers across the study area. The little existing FBOs are not even active, and as such cashew farmers gain little or no knowledge or support from the FBOs to increase production. However, more needs to be taken to re-organize cashew farmers into vibrant FBOs to boost the expected productivity of cashew production in Northern Ghana. Generally in the Northern part of Ghana, people who are educated to a relatively far extend have little interest in farming. They are more exposed to other income-generating activities, and as such, would like to invest in them either than farming or cashew production. Access to Credit, the distance of farm from home and distance of farm from the market has a positive and significant bearing on cashew production. This suggests that more works needs to be done on these factors to ensure the sustained contribution of these factors to the development of the cashew in the northern sector.

Household size, access to extension services and FBO membership has a positive and significant impact on mango production, contrary to the age of respondent, which has a negative and significant effect on mango production. More attention is paid to mango production, which is mostly dominated by the aged, in terms of organized groups and technical service provision. It was also observed in field that projects that came in to the northern region did well in organizing producers in to groups and dealt with them as such.

With regards to income and expenditure per capita as indicator variables for welfare measurement, perennial crop production has a significant influence on the welfare of farmers. This result was revealed through the PSM, after the indicator variables for both observed and unobserved groups satisfied the statistical conditions after the matching process. This implies that perennial crops in the northern serves as a strong contributor to the welfare of farmers and should be treated with all economic, environmental and social considerations to boost its productivity and economic returns.

It was also observed through the CMP analysis of the data collected that, perennial crops contribute significantly to food security and livelihood diversification in the Northern region. The study further has it that the proportion of income earned from the production of perennial crops significantly contributes to livelihood diversification. This implies that perennial crop, when given much attention, can help create more income for farmers to diversify into other income-generation activities. This can make farmers, in the medium to short-run, both economically and financially independent.

5.3 Recommendations

Based on the study results and the subsequent conclusions made, some important policy recommendations emerge for government and other stakeholders in the area of perennial or tree crop development.

Since cashew and mango production are found to be substitutes, programs and policies tailored at the development of the two crops should be strategic. For instance, the Planting for Export and Rural Development Programme (PERDP) by the government of Ghana, and other programmes, should focus on areas that each of these crops has comparative advantage concerning climate, human labour, producer preference, among others. Thus the promotion of mango and cashew should be location and other factor-specific and not simultaneously. This will help to realize the full yield potential of each crop as well as the full utilization of resources.

Programs and policies should be designed towards strengthening the facilitation of FBOs and building the capacities of youth in cashew and mango production. Access to credit and extension services should be intensified to enable perennial crop farmers' increase their output. The government can take up these by recruiting and training more agricultural extension agents in the area of tree crop development. Also, leveraging on the existing financial institutions and agro-inputs and processing industries to provide both financial and input support to farmers to boost their productivity is highly recommended.

There is the need for more educational campaign and sensitization on perennial crop production to enable farmers to become fully aware and appropriately adopt the perennial crop production (mango and cashew) as an alternative means to livelihood and food security

5.4 Recommendations for Future Research

Evidence from the literature and the empirical analysis in this study still revealed large knowledge gaps. Therefore, future research should focus on the impact of perennial crops on soil and water conservation practices and farmers' wellbeing by using more than two crops. Another area that future research should also look at has to do with profit analysis of perennial crops by targeting specific crops. Other future studies could also intensively explore not just the effect of government's programs in the development of the tree crop sector in the country but also, on the value chain analysis of the perennial crop sector.

References

Abdulai, A. a. (2001). Tehnical Efficieency During EconomicReform in Nicaragua: Evidence from Farm Household Survey Data. *Economic Systems*, 25:113-125.

Abreu, A. &. (2013). Asset Indices as a Proxy for Poverty Measurement in African Countries: Reassessment. *In Conference African Economic Development: Measuring Success and Failure.* Vancouver: British Columbia, Canada.

Acquaye, J. A. (2018). Export Orientation and Export Performance: The Role of Marketing Capabilities and Brand Orientation . *Doctoral dissertation, University Of Ghana*.

Adams, F. A. (2019). Financial analysis of small-scale mango chips processing in Ghana. *Cogent Food & Agriculture*, 5(1), 1679701.

Adeigbe, O. O. (2015). A review on cashew research and production in Nigeria in the last four decades. *Scientific Research and Essays*, 10(5), 196-209.

African Cashew Alliance. (2010). A Value Chain Analysis of Cashew Sector in Ghana. 48.

Aitken, A. (2019). Measuring welfare beyond GDP. . *National Institute Economic Review*, 249, R3-R16.

Ajayi, O. C. (2012). Policy support for large-scale adoption of agroforestry practices: experience from Africa and Asia. In Agroforestry-The Future of Global Land Use . *Springer, Dordrecht.*, (pp. 175-201).

Akesse-Ransford, G. E. (2016). Insect Diversity Of Cocoa Under Different Management Systems In Central And Eastern Regions Of Ghana." PhD diss., University of Ghana. *University of Ghana, Legon*.

Andrews, D. S. (2011). Housing markets and structural policies in OECD countries.

Armah, E. K. (2018). Productivity and Resource-Use-Efficiency of Cashew Production in Ghana (Doctoral dissertation, University Of Ghana).

Azumah, S. D. (2017). Contract farming and the adoption of climate change coping and adaptation strategies in the northern region of Ghana. *Environment, Development and Sustainability*, 23.

Bayat, A. (2020). *Life as politics.* . Stanford: Stanford University Press.

Béné, C. N.- W. (2014). Resilience, poverty and development. . *Journal of international development* , 26(5), 598-623.

Coelli, T. J. (2005). An Introduction to Efficiency and Productivity Analysis. 2nd Edition. *Springer*.

Cook, D. &. (2021). An appraisal of interlinkages between macro-economic indicators of economic well-being and the sustainable development goals. *Ecological Economics* , 184, 106996.

Costa, C. &. (2019). The Cashew Value Chain in Mozambique.

Costa, S. &. (2017). Manual for small-scale cashew cultivation in Sierra Leone. *Millan, Italy*.

Daniel A. Kane, P. R. (2016). A Systematic Review of Perennial Staple Crops Literature Using Topic Modeling and Bibliometric Analysis. *PLOS ONE | DOI:10.1371/journal.pone.0155788*.

Danso-Abbeam, G. &. (2019). Does fertiliser use improve household welfare? Evidence from Ghana's cocoa industry. *Development in Practice*, 29(2), 170-182.

Debela, A. T. (2009). Impact of Perennial crop Cropping on Food Crop Production and Productivity. 34.

DeeHan, L. R. (2015). Perennial Crops Are a Key to Sustainably Productive Agriculture. *Research Gate*, 11.

Dendena, B. &. (2014). Cashew, from Seed to Market: a Review. *Agronomy for sustainable development*, 34(4), 753-772.

Deters, J. (2017). *Global leadership talent management: Successful selection of global leadership talents as an integrated process.* Emerald Group Publishing.

Deutz, A. P. (2018). Adoption of conservation practices and precision technologies in South Dakota: An empirical analysis. . *South Dakota State University.*

Donkor, A. J. (2012). Climate variability and yields of major staple food crops in Northern Ghana. *African Crop Science Journal*, 20, 349-360.

Échevin, D. (2013). Measuring vulnerability to asset-poverty in sub-Saharan Africa. *World Development*, 46, 211-222.

FAO. (2013). The State of Food Insecurity in the World. Multiple Dimensions of Food Security.

FAO. (2014). *P E R E N N I A L C R O P S F O R F O O D S E C U R I T Y P R O C E E D I N G S O F T H E F A O E X P E R T W O R K S H O P.*

FAO. (2014). *P erennial Crops for Food Security:Proceedings of the FAO Expert Workshop.*

Feliciano, D. (2019). A review on the contribution of crop diversification to Sustainable Development Goal 1 "No poverty" in different world regions. *Sustainable development* , 27(4), 795-808.

Fitzpatrick, J. (2011). *Cashew processing equipment study.* Accra.

Fold, N. (2008). Transnational sourcing practices in Ghana's perennial crop sectors. *Journal of Agrarian change*.

Foresight. (2011). *The Future of Food and Farming: Challenges and choices for global sustainability.* London: The Government Office for Science.

Frölich, M. H. (2017). The finite sample performance of semi-and non-parametric estimators for treatment effects and policy evaluation. *Computational Statistics & Data Analysis*, 115, 91-102.

Fuerst, F. &. (2011). The impact of Energy Performance Certificates on the rental and capital values of commercial property assets. *Energy policy* , 39(10), 6608-6614.

Funnell, S. C. (2011). *Purposeful program theory: Effective use of theories of change and logic models (Vol. 31).* John Wiley & Sons.

GEXIM. (2018). Stakeholder Newsletter. *Vol.1*.

Ghosh, T. A. (2013). Using nighttime satellite imagery as a proxy measure of human well-being. . *sustainability*, 5(12), 4988-5019.

Glazerman, S. &. (2016). Glazerman, S., & Dotter, D. (2016). Market Signals: Evidence on the Determinants and Consequences of School Choice from a Citywide Lottery. *Mathematica Policy Research, Inc.*, Working Paper 45.

Glover, J. D. (2012). Agriculture: Plant Perennial to Save African Soils. *Research Gate*.

Godfray, J. C. (2010). Food Security: The Challenge of Feeding 9 Billion People. *Science*, 8.

Goldsmith, E. B. (2015). *Social influence and sustainable consumption.* Springer International Publishing.

Grabowski, P. P. (2014). Resource constraints and partial adoption of conservation agriculture by hand-hoe farmers in Mozambique. *International Journal of Agricultural Sustainability*, 12(1), 37-53.

Groothius, R. (2016). Decision-making of Rural Farm Households Growing Cashew or Shea.

GSS. (2010). *Population and housing census 2010.* Accra: Ghana Statistical Service.

Guentang, L. S. (2018). Adoption of bioenergy crops, income and contract preferences among farmers in northern Ghana: the case of Jatropha. *Doctoral dissertation, University of Ghana).*

Gutierrez, V. &. (2015). Funding forest landscape restoration using a business-centred approach: an NGO's perspective.

H. Charles J. Godfray, 1. J. (2010). Food Security: The Challenge of Feeding 9 Billion People. *American Association for the Advancement of Science*, 8.

Hitt, M. A. (2017). *Organizational behavior.* John Wiley & Sons.

Howe, L. D. (2012). Measuring socio-economic position for epidemiological studies in low-and middle-income countries: a methods of measurement in epidemiology paper. . *International journal of epidemiology* , 41(3), 871-886.

Hristos, D. T. (2009). Publication Selection Bias in Minimum- Wage Research? A Meta- Regression Analysis. *An International Journal of Employment Relations*, 406-428.

Ifeoma, I. &. (2014). Assessment of food security situation among farming households in rural areas of Kano state, Nigeria. *Journal of central European agriculture.*

Kane, D. A. (2016). A Systematic Review of Perennial Staple Crops Literature Using Topic Modeling and Bibliometric Analysis. *Plus One*, 18.

Kaseke, T. (2017). The Effectiveness of subsistence farming on food security: A case study of two wards in a district. *Doctoral dissertation, BUSE*.

Kazianga, H. &. (2013). Gender, social norms, and household production in Burkina Faso. *Economic Development and Cultural Change*, 61(3), 539-576.

Kranjac-Berisavljevic, G. B. (1999). Rethinking natural resource degradation in semi-arid sub-Saharan Africa: The case of semi-arid. *Overseas Development Institute/University for Development Studies*.

Kuyah, S. W. (2019). Agroforestry delivers a win-win solution for ecosystem services in sub-Saharan Africa. A meta-analysis. *Agronomy for sustainable development*, 39.

Larkin, P. N. (2014). Progress in developing perennial wheats for grain and grazing:. *Crop Pasture Science*.

Laube, W. S. (2011). Smallholder adaptation to climate change: Dynamics and limits in Northern Ghana. *Climatic Change,* 21.

Lazos- Chavero, E. Z.- C. (2016). Stakeholders and tropical reforestation: challenges, trade- offs, and strategies in dynamic environments. *Biotropica*, 48(6), 900-914.

Li, M. S. (2019). Optimization of agricultural water–food–energy nexus in a random environment: an integrated modelling approach. *International Journal of Energy and water resource*.

Lopez, A. M. (2021). TOWARDS A MODEL FOR PUBLIC PRIVATE PARTNERSHIP (P3) SUCCESS: UNDERSTANDING THE CRITICAL SUCCESS FACTORS OF PUBLIC PRIVATE PARTNERSHIPS (P3) FOR LOCAL GOVERNMENT SERVICES AND INFRASTRUCTURE DELIVERY . *Doctoral dissertation, FLORIDA INTERNATIONAL UNIVERSITY*.

Mariano, M. J. (2012). Factors influencing farmers' adoption of modern rice technologies and good management practices in the Philippines. *Agricultural systems.*, 110, 41-53.

Matchaya, G. N.-5. (2014). Agricultural sector performance in Malawi. Regional and Sectoral Economic Studies . 14(2), 141-56.

Menon, M. P. (2016). *An asset-based indicator of wellbeing for a unified means testing tool: Money metric or counting approach?* Luxembourg: Luxembourg Institute of Socio-Economic Research (LISER) Working Paper Series, 9.

Micca, J. a. (2016). Overcoming Constraints in Mango Production in Ghana. *International Journal of Agricultiral Economics*.

Miles, J. A. (2012). Management and organization theory:. *A Jossey-Bass reader* , Vol. 9.

Mumin, Y. (2017). Small-Scale Irrigation, Farm Income and Access to Essential Services in the Busa Community of the Upper West Region of Ghana. *Ghana Journal of Development Studies*, 14(1), 99-122.

Muzari, W. G. (2012). Muzari, W., Gatsi, W., & Muvhunzi, S. (2012). The impacts of technology adoption on smallholder agricultural productivity in sub-Saharan Africa: A review. . *Journal of Sustainable Development*, 5(8), 69.

Ntsiful, N. (2010). Out grower oil palm plantations scheme by private companies and poverty reduction in Ghana. *PhD Thesis*.

Ogazi, L. E. (2010). African Development and the Influence of Western Media:Breaking The Cycle Of"Ravaging The African Continent. *Xlibris Corporation.*

Osabohien, R. M. (2019). Agriculture development, employment generation and poverty reduction in West Africa. *The Open Agriculture Journal*, 13(1).

Paul, C. W. (2017). Agroforestry versus farm mosaic systems–Comparing land-use efficiency, economic returns and risks under climate change effects. *Science of the Total Environment* , 587, 22-35.

Peprah, P. A. (2018). The syncline and anticline nature of poverty among farmers: Case of cashew farmers in the Jaman South District of Ghana. . *Journal of Poverty*, 22(4), 355-377.

Poirier, M. J. (2020). Approaches and alternatives to the wealth index to measure socioeconomic status using survey data: a critical interpretive synthesis. *Social Indicators Research*, 148(1), 1-46.

Prajapati, H. R. (2020). Organic Farming: Economics, Policy and Practices. *Sage Publications Pvt. Limited.*

Robidoux, M. L. (2018). he costs of localfood procurement in a Northern Canadian First Nation community: an affordable strategy to foodsecurity? *Journal of Hunger & Environmental Nutrition*,, 22.

Rogé, T. D. (2017). Perennial grain crops in the West Soudanian Savanna of Mali: perspective from agroecology and gendered species. *International Journal of Agricultural Sustainability*, 21.

Ross, C. (2014). The plantation paradigm: colonial agronomy, African farmers, and the global cocoa boom, 1870s–1940s. *Journal of Global History*, 9(1), 49-71.

Scott, R. (2010). Instrumental variable methods for adressing selection bias. *SAS Press*.

Smits, J. &. (2015). The international wealth index (IWI). *Social indicators research*, 122(1), 65-85.

Streiner, D. L. (2015). *Health measurement scales: a practical guide to their development and use.*. Oxford University Press, USA.

Sulemana, I. &. (2014). Farmer identity, ethical attitudes and environmental practices. *Ecological Economics*, 98, 49-61.

Svensson, G. F. (2018). Framing the triple bottom line approach: Direct and mediation effects between economic, social and environmental elements. *Journal of cleaner production*, 197, 972-991.

Tregeagle, D. T. (2017). *The Dynamics of Perennial Crop Production and Processing*. Berkeley: University of California.

Trade-offs between seed output and life span – a quantitative comparison of traits between annual and perennial congeneric species. (2016). *1Department of Crop Production Ecology, Swedish University of Agricultural Sciences, Uppsala 75007, Sweden; 2Department of Physical Geography, Stockholm University, Stockholm 10691,.*

UN. (2015). Transforming our world. The 2030 Agenda for Sustainable Development . 41.

Uwajumogu, N. N. (2019). Response of economic diversification to gender inequality: Evidence from Nigeria. *International Journal of Social Sciences and Economic Review*, 61-72.

Van Melle, C. &. (2013). Comparative analysis of mango value chain models in Benin, Burkina Faso and Ghana. Rebuilding West Africa's Food Potential. *FAO/IFAD*.

Vico, G. S. (2016). Trade-offs between seed output and life span – a quantitative comparison of traits between annual and perennial congeneric species. *New Phytologist*, 11.

Walks, A. (2016). Homeownership, asset-based welfare and the neighbourhood segregation of wealth. *Housing Studies* , 31(7), 755-784.

Weih, M. (2013). *PERENNIAL ENERGY CROPS: GROWTH AND MANAGEMENT.* Uppsala: Swedish University of Agricultural Sciences, Uppsala.

Will, K. (2019). Per Capita Income. *Invstopedia*.

World Bank. (2016). *Prevalence, Economic Contribution, and Determinants of Trees on Farms in Sub-Saharan Africa.* World Bank Group.

World Bank. (2017). Enabling Business of Agriculture.

Yaro, J. A. (2017). Agricultural commercialisation models, agrarian dynamics and local development in Ghana. *The Journal of Peasant Studies* , 44(3), 538-554.

Yussif, M. M. (2019). Social networks and integrated soil fertility management adoption: effects on maize yields and food security of farmers in Northern Region. *Doctoral dissertation*.

Zakari, A. (2012). National Mango Study. *International Trade Center: Geneva, Switzerland.*

APPENDICES

Appendix 1: Table of Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Settle_Yrs	386	3.008	8.813	1	50
Sex_Resp1	386	0.894	0.309	0	1
Age_Resp2	386	47.687	11.674	23	81
HH_Size3	386	11.228	5.219	2	46
HH_Labour4	386	7.531	3.830	1	36
Inc_Annual	386	17671.320	13470.670	1000	208000
Perennial	386	0.554	0.498	0	1
Pro_HHInc	386	8854.181	4471.580	0	75000
Cr_Access	386	0.368	0.161	0	1
Farm_DistH	386	4.228	3.345	0.5	21
Farm_DistM	386	10.984	5.452	1	30
Access_Ext	386	0.580	0.494	0	1
Ext_Ntimes	386	1.236	1.208	0	6
FBO	386	0.390	0.187	0	1
Actvty_OfFam	386	0.222	0.052	0	1
NonF_Amt	386	1065.191	271.917	0	12000
Yrs_Sch5	386	5.664	5.010	0	20
Gexp	386	2083.083	1126.081	450	10600
Cashew_only	386	0.329	0.470	0	1
Mango_only	386	0.119	0.324	0	1
Both_CM	386	0.101	0.302	0	1
Asset_Value	386	6114.024	3250.060	9	100220
LDI	385	0.535	0.234	0	1
CDI	386	0.294	0.307	0	1
Mar_Stats	386	1.104	0.672	0	5
PerFarm_Age	386	8.802	7.699	3	30
EXp_PrCrop	386	8.604	7.482	1	40
ExP_AnnCrop	386	24.244	12.456	1	70
Acres_PrCrop	386	9.857	5.403	1	70

Appendix 2: Results of Bavariate Proibit Estimates

Variable	Coef.	Std. Err.	Z	P>z	[95% Conf.	Interval]
Cashew_only						
Settle_Yrs	0.0150	0.0081	1.85	0.064	-0.0009	0.0308
Sex_Resp	-0.3761	0.2503	-1.5	0.133	-0.8668	0.1146
Age_Resp	0.0112	0.0077	1.46	0.145	-0.0039	0.0263
HH_Size	-0.1066	0.0208	-5.13	0	-0.1473	-0.0659
Inc_Annual	0.0000	0.0000	-0.99	0.324	0.0000	0.0000
Cr_Access	0.1767	0.2287	0.77	0.44	-0.2715	0.6250
Farm_DistH	0.0344	0.0273	1.26	0.207	-0.0190	0.0879
Farm_DistM	0.0263	0.0159	1.65	0.099	-0.0049	0.0576
Access_Ext	-0.1156	0.1638	-0.71	0.48	-0.4366	0.2054
FBO	-0.6871	0.2332	-2.95	0.003	-1.1442	-0.2301
Yrs_Sch	-0.0281	0.0159	-1.77	0.077	-0.0593	0.0031
Pro_HHInc	0.0000	0.0000	2.3	0.021	0.0000	0.0001
PerFarm_Age	0.0550	0.0094	5.83	0	0.0365	0.0735
_cons	-0.2779	0.4165	-0.67	0.505	-1.0943	0.5384
Mango_only						
Settle_Yrs	-0.0227	0.0136	-1.66	0.096	-0.0493	0.0040
Sex_Resp	0.3457	0.4233	0.82	0.414	-0.4838	1.1753
Age_Resp	-0.0235	0.0104	-2.26	0.024	-0.0440	-0.0031
HH_Size	0.0491	0.0211	2.33	0.02	0.0078	0.0905
Inc_Annual	0.0000	0.0000	1.14	0.253	0.0000	0.0000
Cr_Access	-0.0033	0.2539	-0.01	0.99	-0.5010	0.4944
Farm_DistH	0.0320	0.0311	1.03	0.303	-0.0289	0.0929
Farm_DistM	-0.0332	0.0210	-1.58	0.113	-0.0744	0.0079
Access_Ext	0.5593	0.2252	2.48	0.013	0.1178	1.0007
FBO	0.6676	0.2203	3.03	0.002	0.2358	1.0994
Yrs_Sch	0.0304	0.0172	1.77	0.077	-0.0033	0.0641
Pro_HHInc	0.0000	0.0000	-1.37	0.171	-0.0001	0.0000
PerFarm_Age	0.0427	0.0108	3.94	0	0.0215	0.0640
_cons	-1.8984	0.6045	-3.14	0.002	-3.0833	-0.7136

Appendix 3: Logit Estimates for Predicted Scores of the PSM

Variable	variable dy/dx	Std. Err.	z	P>z	[95%	C.I.]
Sex_Resp*	0.1192	0.102	1.17	0.242	-0.0803	0.3188
Age_Resp	0.0063	0.003	2.1	0.035	0.0004	0.0121
HH_Size	0.0284	0.014	2.06	0.039	0.0014	0.0555
HH_Lab~r	-0.0958	0.020	-4.75	0.000	-0.1354	-0.0563
Inc_An~l	0.0000	0.000	5.75	0.000	0.0000	0.0000
Cr_Acc~s *	0.3163	0.057	5.52	0.000	0.2040	0.4286
Farm_D~H	0.0469	0.010	4.61	0.000	0.0270	0.0668
FBO*	0.2305	0.062	3.72	0.000	0.1092	0.3518
Yrs_Sch	-0.0106	0.006	-1.89	0.058	-0.0215	0.0004
NFam_Inc	0.0001	0.000	1.18	0.237	0.0000	0.0002
logASSTV	-0.0735	0.024	-3.07	0.002	-0.1205	-0.0265

Appendix 4: Test of equality of means of each variable before and after matching.

variable	Unmatched Sample			Matched Sample			
	Perennial	Annual	Diff. p-values	Perennial	Annual	Diff. p-values	%reduction bias
HHDS	115.94	103.85	0.00[a]	116.24	106.41	0.00[a]	18.7
Sex of respondent	0.90	0.88	0.64	0.90	0.83	0.05[b]	-346.5
Age of respondent	47.13	46.01	0.38	47.20	45.18	0.10[c]	-80.1
Household size	10.53	11.32	0.13	10.52	10.25	0.56	65.3
Household labour	6.85	7.78	0.01[a]	6.83	6.56	0.42	71.6
Annual income	12521.00	8919.00	0.00[a]	12573.00	9535.10	0.00[a]	15.7
Access to credit	0.19	0.05	0.00[a]	0.19	0.28	0.04[b]	35.6
Distance of farm from home	4.34	3.50	0.01[a]	4.34	4.08	0.39	68.3
Belonging to an FBO	0.21	0.10	0.01[a]	0.21	0.33	0.01[a]	-7.8
Completed years of education	4.49	5.06	0.33	4.52	4.26	0.64	53.5

Appendix 5: Overall matching quality indicators before and after matching

Sample	Ps R2	LR chi2	p>chi2	MeanBias	Total %i n Bias Reduction
Unmatched	0.276	64.54	0.000[a]	15.2	
Matched	0.038	19.61	0.151	4.4	72.15

[a] (1% level of significance)

Appendix 6: Robustness of the ATT estimates to unobserved heterogeneity using rbounds test.

Gamma	Sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0.1585	-0.0363	-0.0363	-0.1075	36867.00
1.1	0	0.3318	-0.0560	-0.0163	-0.1300	0.0588
1.2	0	0.5321	-0.0737	0.0031	-0.1493	0.0784
1.3	0	0.8401	-0.0913	0.0209	-0.1678	0.0784
1.4	0	0.8401	-0.1089	0.0377	-0.1841	0.1130
1.5	0	0.9201	-0.1247	0.0534	-0.1990	0.1297
1.6	0	0.9634	-0.1384	0.0672	-0.2151	0.1445
1.7	0	0.9844	-0.1513	0.0806	-0.2299	0.1591
1.8	0	0.9938	-0.1642	0.0923	-0.2438	0.1725
1.9	0	0.9977	-0.1753	0.1034	-0.2578	0.1860
2	0	0.9992	-0.1856	0.1148	-0.2699	0.1991
2.1	0	0.9997	-0.1955	0.1258	-0.2814	0.2114
2.2	0	0.9999	-0.2056	0.1364	-0.2927	0.2226
2.3	0	1	-0.2265	0.1457	-0.3035	0.2328
2.4	0	1	-0.2265	0.1553	-0.3132	0.2428
2.5	0	1	-0.2351	0.1651	-0.3234	0.2533
2.6	0	1	-0.2441	0.1729	-0.3234	0.2627
2.7	2E-13	1	-0.2531	0.1819	-0.3424	0.2712
2.8	3E-14	1	-0.2691	0.1898	-0.3504	0.2795
2.9	4E-15	1	-0.2760	0.1983	-0.3583	0.2877
3	6E-16	1	-0.2760	0.2055	-0.3661	0.2959
3.1	1E-16	1	-0.2829	0.2132	-0.3745	0.3045
3.2	0	1	-0.2897	0.2209	-0.3824	0.3116
3.3	0	1	-0.2967	0.2270	-0.3914	0.3204
3.4	0	1	-0.3035	0.2328	-0.3989	0.3280
3.5	0	1	-0.3093	0.2391	-0.4072	0.3364

Appendix 7: Heterogeneous impacts among of perennial crop farmers

Variable	Coefficient	Standard error
Perennial	0.011 [a]	0.005
HHDS	0.002	0.000
Sex of respondent	0.000 [a]	0.007
Age of respondent	0.006[a]	0.000
Household size	0.018[a]	0.001
Household Labour	0.002[a]	(51.240)
Annual income	0.000[a]	2.807
Credit access	0.313[a]	0.007
Distance of farm from		
home	0.041[a]	0.001
FBO	0.195[a]	0.006
Years spent in school	-0.012[a]	0.000
_cons	0.082[a]	0.013
N	351	
R^2	0.98	
F	12.89a	

Appendix 8: Study Questionnaire

University for Development Studies

Faculty of Agriculture, Food and Consumer Sciences

Department of Food Economics

Perennial Crop Production: Implications on Farmers' Welfare in the Northern Region of Ghana

Introduction:

Hello! My **name** is ……………………………, a research assistant from the **University for Development Studies**. We are conducting a research in this community and I will very much appreciate your time if you could be part of this exercise. The research is concerned with how perennial crop production affects the welfare of farmers in the northern region of Ghana. The interview will take approximately 30 to 45minutes in all and the information you provide will be treated **confidential** as possible and your **anonymity is guaranteed**. Do I have your permission to start the interview?

[0] No I don't want to participate in the interview

[1] Yes I do want to participate in the interview

Date of interview:	**Enumerator's ID**:	**Respondent Telephone:**
Name of District:	**Name of Community**:	**Community ID**:
Name of Household head:	**Household ID**:	**Age of Household head:**

SECTION A: GENERAL INFORMATION

A1	A2	A3	A4	A5	A6	A7	A8
What is/are the main languages spoken at home?	What is the ethnicity of the farmer?	What type of marriage is the farmer practicing?	What is the settlement status of the farmer in the community? >> **A5 if Settler**	For how long have you settled in the community?	What is the highest level of completed education attained by the farmer?	Is the household head a male or female?	How many household members are not working? **(very old and children)**
Codes [1] Dagbani [2] Gonja [3] Others (specify)	**Codes** [1] Dagbani [2] Gonja [3] Others (specify)	**Codes** [1] Polygynous [2] Monogamous [3] Other (specify)	**Codes** [1] Native [2] settler		**Codes** [1] Tertiary [2] Secondary [3] Primary [4] Non-formal education [5] No formal education	**Codes** [1] Male-headed [2]Female-headed	

SECTION B: SOCIO-DEMOGRAPHIC CHARACTERISTICS

B1	B2	B3	B4	B5	B6
What is the age of the respondent	What is the respondent's completed years of schooling	What is the respondent's Religion	What is the respondent's marital status	What is the household size	What is the active labor force within the household
		Codes [0] no religion [1] Christian [2] Muslim [3] ATR [4] other (specify)	**Codes** [0] Never married [1] Married [2]Consensual union [3]separated [4]Divorced [5]Widow		

B7	B8	B9	B10	B11
What is the annual income of respondent?	What is the monthly income of respondent?	What is the distance of farming community from the district capital (Km)	Do you have access to extension services?	If yes to **B10,** how many times in a year?
			Codes [0] No [1] Yes	

SECTION C: Determinants of Various Sources Credit Participation By Women Farmers

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Which of the following sources of credit do you have access to? (multiple response)	How much credit did you receive from VSLA last farming season?	How much credit did you receive from SUSU last farming season?	How much credit did you receive from MF last farming season?	How much credit did you receive from Banks last farming season?	How much credit did you receive from Family and friends last farming season?	What is the total amount of credit you have received?	Have you been able to pay back credit received during last farming season?	If no why?	How many family labors assist you in the farm?
Codes [1] VSLA [2] SUSU [3] MF [4] Banks [5] Family &friends							**Codes** [1] yes [0]No		

C11	C12	C13	C14	C15	C16	C17	C18
What are the inputs used in the farm? (Multiple response)	On average what is the monthly expenditure on inputs?	On average what is the yearly expenditure on inputs?	How many years now have you been farming?	What crop/animal do you farm/rear most	Size/number of land/animal cultivated/reared	What is the output of the crop you cultivated? (No. of 100kg bags/acre	Do you belong to any FBO
Codes [1] Insecticides [2] Pesticides [3] Fertilizer [4] Manure [5] Knapsack sprayer [6] Cutlass							**Codes** [1] yes [0]No

C19	C20	C21	C22	C23
Do you have access to market?	If yes to **C19,** which source? (**Multiple response**)	What is the ownership state of the land used for farming?	Do you participate in any credit program?	If yes to **C22** what is the name of that program?
Codes [0] No [1] Yes	**Codes** [1] local market [2] processor [3] off-taker [4] government	**Codes** [1] inherited [2] rent [3] purchased [4] gift [5] shared	**Codes** [1] yes [0] no	

SECTION D: Agricultural Output on the Welfare of Women Farmers in the Northern Region

D3	D4	D5	D6	D7
What is the monthly non-farm income	What is the annual expenditure on food?	What is the annual expenditure on clothing?	What is the annual expenditure on health?	What is the annual expenditure on others?

D9	D10	D11	D12	D13	D14	D15	D16
In the last 12 months did any member of the household ever not eat a whole day because there wasn't enough food?	In the last 12 months did you ever reduce the quality or quantity of meals because there wasn't enough money for food?	In the last 12 months did any member of the household ever skip meals because there wasn't enough money for food?	In the last 12 months did any member of the household ever hungry but just couldn't afford any food?	How often did this happen?	How many hot meals did you have on the average within the **past 7days?**	In the last 3 months, has the household ever taken a less preferred meal?	Has your household ever received any food aid from gov't or NGOs in the past 12 months?
Codes [0] No [1] Yes [3] Don't Know	**Codes** [1] Yes quality reduced [2] Yes quantity reduced [3] Neither 1&2 [4] Don't Know	**Codes** [0] No [1] Yes [3] Don't Know	**Codes** [0] No [1] Yes [3] Don't Know	**Codes** [1] almost every month [2] some months [3] 1or 2 months [4] Don't Know		**Codes** [0] No [1] Yes [3] Don't Know	**Codes** [0] No [1] Yes [3] Don't Know

How many days in the last 7 days has your household eaten the following foods?

	Food items	Number of days within the week
1	Maize	[ ]
2	Millet/sorghum	[ ]
3	Rice	[ ]
4	Bread/wheat	[ ]
5	Tubers (yam, cassava, plantain, other)	[ ]
6	Groundnut and beans	[ ]
7	Fish eaten as a main food	[ ]
8	Fish powder, small fish (used as Maggi or flavor)	[ ]
9	Red meat (sheep/goat/beef)	[ ]
10	White meat (poultry)	[ ]
11	Vegetable oil, butter, shea butter, fats	[ ]
12	Eggs	[ ]
13	Milk and dairy products (main food)	[ ]
14	Milk in tea	[ ]
15	Vegetables	[ ]
16	Fruits	[ ]
17	Sweets, sugar, honey	[ ]

SECTION E: FAMER HOUSEHOLD EXPENDITURE AND ASSETS

E1	E2	E3	E4
How much does your household spend on food in a regular month?	How much does your household spend on other non-food items in a regular month? (e.g. soap, pomade, clothing)	How much does your household spend on other social expenditure in a regular month? (e.g. weddings, outdooring, funerals)	Other miscellaneous expenditure not part of **G1, G2** and **G3**

Assets	How many do you own?	Is asset in good condition? [0] No [1] Yes	How long have you owned asset? (in years)	How did you acquire asset? [1] Purchased [2] Gift [3] Inherited
Mobile phone				
Bicycle				
Motor bike				
Canoe				
Sewing machine				
Refrigerator				
Blender				
Electric iron				
TV-set				
Radio				
Others (specify)				

THANK YOU FOR THE TIME.

PERENNIAL CROP PRODUCTION: IMPLICATION ON WELFARE OF FARMERS IN NORTHERN GHANA

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[signature]

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