CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

The role of homegardens in ensuring food security in Sahel region: Example from Northern regions in Ghana

MASTER'S THESIS

Prague 2022

Author: Harriet Tweneboah

Supervisor: Ing. Vladimír Verner, Ph.D

Declaration

I hereby declare that I have done this thesis entitled the role of homegardens in ensuring food security in Sahel region: Example from Northern regions in Ghana independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague, 16. April 2021

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Harriet Tweneboah

Acknowledgements

In the first place, I would like to thank my supervisor Ing. Vladimír Verner, Ph.D. for his empathetic guidance and trust throughout the whole process. His support and constructive criticism helped to shape the thesis. Also, I wish to acknowledge the Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague for the mobility grant to students for research. Last, but not least, I would like to express my great appreciation to my family for their support during my studies.

Abstract

Homegardens have become a center for development initiatives by governments, non-governmental organizations as well as development agencies to help in the global challenge of food production and food insecurity especially in developing countries. They embark on this through providing aid and building the local capacity to promote sustainable intensification of homegardens to improve food and cash security of households. This study focused on rural/peri-urban homegardening, its commercialization, contribution of homegardening to total household income, income diversity of the farmers and the food security situation of the farmers. Mixed sampling technique was used to select 120 farmers who were running homegardens. Commercialization was calculated using homegarden commercialization index, which served to categorize the homegardens into more and less market oriented (high and low commercialization levels). Food security was measured via HFIAS Score. We estimated the income diversity of the farmers and the contribution of homegarden to total household income. Probit regression was used to analyze the factors that influence commercialization level of the farmers. Also, the propensity score matching, and endogenous treatment regression model were used to analyze the impact of homegarden commercialization on the food security of the farmers. The results of the study revealed that 52% of the farmers are food secured and the crop species cultivated by majority of the farmers are pepper and maize. The probit regression model showed that age of homegarden head, gender, homegarden size, ownership status of homegarden, and water availability significantly affects homegarden commercialization. The results further showed that homegarden commercialization significantly contributes to food security of farmers in the Upper East region. Other factors that influenced food security of the farmers were gender, years of education, and access to input subsidy. Outcomes from the farmers perception analysis highlighted important role of homegardens in terms of food security and gaining additional income. Major constraints in homegardening were high initial capital of investment, lack of agricultural extension service or support, and destruction of the garden by animals. This study, therefore, argue that governments and development agencies should include and support homegardens in agricultural and rural development policies in Ghana.

Keywords: Functional diversity, Food security, Commercialization, Drivers, Agroforestry

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1. Introduction

Homegardens can be defined as multispecies agroecosystem where different crops, trees and livestock are managed in integration (Kumar & Nair 2004; Weerahewa et al. 2012). Additionally, it is characterized by the complexity of structure and multiple functions (Fernandes & Nair 1986; Eyzaguirre & Watson 2002; Sunwar et al. 2006). Homegarden is considered one of the oldest farming systems after shifting cultivation (McConnell 1992; Puri & Nair 2004; Squire 2004). It is indicated that the homegardens have advanced from one generation to the other to provide food and other household needs such as herbs for medicinal use with the impact of resource constraints specific to countries such as inadequate markets outlets, lack of transportation facilities, population pressure, remoteness of area, limited access to capital and arable lands among others (Kumar and Nair 2006; Pushpakumara 2012). Homegarden has been proven to be a reliable system over the past years that is widely adopted, particularly in rural communities.

Several social and economic benefits can be associated with the gardens; contributes to income generation, improved livelihood, proceeds from sales of crops can be used to access other services such as education and health, promotes savings (Galhena et al. 2013). It is also very vital to the local subsistence economy, food security, and living standard of the rural communities (Kumar & Nair 2004; Shajaat Ali 2005; Abebe et al. 2006; Kumar and Nair 2006)

Also, several studies have documented the role homegardens play in addressing issues of sustainable land use such as nutrient cycling, biodiversity conservation, sustainable soil management, minimal use of artificial inputs, water recycling, waste nutrient, shading, reduction of dust and erosion, poverty reduction, enhance rural employment through additional or off-farm production and addressing food security (Jensen 1993; Blanckaert et al. 2004; Landon-Lane 2004; Albuquerque et al. 2005; Montagnini 2006).

Homegardens are a common part of farming systems in Ghana; they can be found in all the agroecological zones and along the rural-urban gradient (Yiridoe & Anchirinah 2005; Akrofi et al. 2010). Most of the studies on homegardens in Ghana have been related to its contribution to in situ conservation of plant genetic resources, the composition of crop species on gardens in different agroecological zones, the characteristics of traditional knowledge and management system (Yiridoe & Anchirinah 2005; Bennett-Lartey & Asiedu-Darko 2008; Akrofi et al. 2010).

It has become difficult for smallholder households in the developing world to maintain homegardens (Abdoellah et al. 2006). Agriculture has become increasingly commercialized and industrialized, and off-farm pressures have dominated food systems across many parts of the globe. Policies and markets encourage farmers to commercialize and engage more directly with buyer–driven commodity chains (Reardon et al. 2009; Auld 2010).

In recent times, there have been many initiatives by governments, non-governmental organizations, and development agencies to help in the global challenge of food production and food insecurity, especially in developing countries. They embark on this through providing aid and building the local capacity to increase productivity and improve homegardens (Landon-Lane 2004; Keller 2010). Food security has become a significant concern as the global population is projected to reach 9 billion in 2050, and more sustainable food production systems need to be incorporated to meet the ever-growing demand for food (FAO 2012).

In the context of continuing rural poverty and food security in developing countries, homegardens contribute immensely to the food security and conservation of biodiversity, especially among poor rural communities (Kumar & Nair 2004; Yiridoe & Anchirinah 2005). Homegarden is seen as one of the means to address the global challenge concerning food security in developing countries due to its value and potential (Buchmann 2009; Weerahewa et al. 2012).

From a geographical perspective, there is a lack of studies from the northern areas of Ghana regarding the role of homegarden and its commercialization on household food security. The

northern part of Ghana is known to be producing a greater percentage of Ghana's food production. Yet, the region faces a high level of poverty, food insecurity, and low living standards. Several considerations need to be taken to address the issues of poverty, food insecurity and improvements in the livelihoods of rural communities in the Upper East Region of Ghana. The best strategy to address these issues depends on the existing social, political, and economic conditions and resource availability (Galhena et al. 2013). In the context of continuing rural poverty and growing environmental contamination in the Upper East region, understanding homegarden commercialization is an essential issue for scholars, smallholder farmers, and policy makers.

Our study focused on rural homegardening, its commercialization, the contribution of homegardening to total household income, income diversity of the farmers and the food security situation of the farmers. The result of the study could help policy makers and the government make policies that will enhance gardening among rural farmers who do not have access to ample farmlands to benefit from the Government policy such as Planting for Food and Jobs.

2. Literature review

This study contributes to the rational choice theory, which can be traced to Adam Smith in his book “An Inquiry into the Nature and Causes of the Wealth of Nations”. The theory highlights that the farmers will perform a cost-benefit analysis to determine whether the choice is correct or not (Gibbs & Coleman 1990). The rational choice theory assumes that;

- All choices are rational and are decided based on costs and benefits considerations.
- The benefits of the option or choice must be greater than the cost of the choice.
- When the value of the benefit falls below the cost, the person will stop the action.
- Individuals will use the resources that they have to optimize their benefits
- All actions are rational and are made due to considering costs and rewards.

2.1 Definition and characteristics of homegardening

Homegardens are predominantly small-scale subsistence agricultural systems (Fernandes & Nair 1986). The beginning of modern agriculture can be linked to subsistence production systems that started in smaller plots of land around the household. These gardens have survived the test of time and continued to play an essential role in providing food and income for households (Marsh 1998). Generally, homegardening is defined as cultivating a small plot of land near the household home or within walking distance from home (Kumar and Nair 2006; Pushpakumara 2012). They can be described as a mixed cropping system encompassing fruits, vegetables, spices, plantation crops, ornamental, herbs, medicinal plants, and livestock that can serve as an additional source of food and income. Kumar & Nair (2004) acknowledged that there is no standard definition for "homegarden" but summarized homegarden as "a special, multi-story combination of various crops and trees, sometimes in combination with domestic animals, near the homesteads".

Marsh (1998) and listed five identifying characteristics of homegardens:

1) A homegarden is located near the residence

2) A homegarden contains a high diversity of plants
3) Homegarden production is supplemental rather than a main source of family consumption and income
4) Homegarden occupies a small area
5) Homegardens are a production system that the poor can easily enter at some level

Homegardens are divided into tropical and temperate, ecologically (Niñez 1984). While there are some similarities, each homegarden is unique in functionality, structure, and composition (Rambo & Sajise, 1984; Fernandes & Nair 1986) because they depend on the availability of family resources and preferences and skills (Galhena et al. 2013).

Homegarden consists of various plant and animal species that symbolize the social and cultural background of different societies. Homegardens demonstrate the rich indigenous knowledge by selecting plants and the farming systems used by the local community. Also, homegardens serve as a repository for preserving, protecting, and transferring indigenous crop and livestock production skills and knowledge from generation to generations (Moreno-Black et al. 1996; Kimber 2004). Homegardens help in building social capital in rural communities. Social capital is created through the interactions in the homegarden (Blanckaert et al. 2004).

2.2 Determinants of homegarden commercialization

The commercialization of a homegarden depends on several economic, social, and environmental factors. Specially, the commercialization of agricultural goods and services is dependent on three main aspects of a farm (Mariyono et al. 2017). Several studies have explored the commercialization of agricultural goods. The influence of farmers' demographic and institutional characteristics on the commercialization of vegetables has been explored (Mariyono 2018). The availability of extension service to a farm positively influences the level of commercialization (Rubhara & Mudhara 2019). The market characteristics such as distance

to market and farmers' demographic characteristics were found to affect the extent of commercialization of urban fam vegetables (Akinlade et al. 2016).

Similarly, Abdullah et al. (2019) investigated the determinant factors influencing smallholder rice farmers and discovered that farmers' household characteristics, such as household size, off-farm income, and institutional supports like access to credit, affected commercialization. Ochieng et al. (2016) and Jerop et al. (2018) concluded that the commercialization of finger millet was determined by farm loss due to pests and disease, the farmer's education level, and farm size. Farms owned by males were relatively highly commercialized; thus, the gender of farmers influences the level of commercialization (Rubhara & Mudhara 2019).

Further, the studies on the commercialization of animal farm products found that guinea fowl's commercialization was impacted by the availability of extension services, input quality, and used technology for production (Moreki & Radikara 2013). The experience of a farmer, losses due to outbreak, input quantity used, number of family labour involvement, product losses, and training or advisory services significantly affect the commercialization of indigenous chicken (Maumburudze et al. 2016; Mufeet et al. 2018). Identified influential factors of the commercialization of homegarden retrieved from the literature have been summarized as a conceptual framework illustrated below in Figure 1.

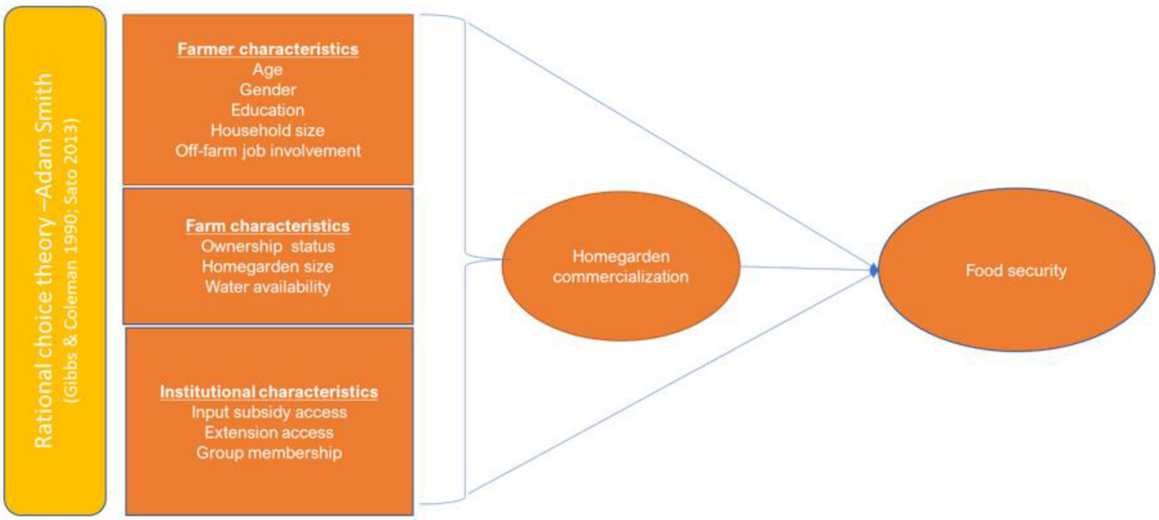

Figure 1. Theoretical and conceptual framework

2.3 Food security defined

Agricultural commodity prices have, on average, remained relatively high in the past decades hence affecting food security (FAO 2013). The Food Price Index estimates the monthly change in international food commodities such as dairy, sugar, cereals, vegetable oil and meat (FAO 2013). The definition of food security has gone through several modifications to reflect government policies changes in the world. Food security was initially defined in 1974 by the UN as "the availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to balance variation in production and prices". The focus of the definition of food security in 1975 by the UN was on price stability of basic foodstuff at both international and national levels without attention to the other pillars of food security. The FAO revised the definition of food security in the World Food Summit of 1996, and the purpose was focused on all the dimensions or pillars of food security. The description

of food security by the FAO in the 1996 World Food Summit reads as, “a situation that exists when all people at all times have physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preference for a healthy and active life”.

2.4 How Household Food Security is Determined

Several researchers have discussed various methods for measuring household food security. Food security is calculated by estimating the total/gross food stocks produced or purchased for household consumption over a period, then evaluating the growth or reduction in food stocks over that same period (Maxwell 1996). This method assumes that the food that has disappeared from the household has been consumed. A limitation to this method is that it does not consider food loss and food waste. "Food loss is defined as the reduction in quality or quantity of food whiles food waste refers to discarding of food that is safe and nutritious for human consumption" (FAO 2018). Food loss is a crucial aspect of food security in developing countries, where 40% of the food is lost due to poor post-harvest handling (FAO 2018). Failure to account for food loss may lead to a misleading result. Food lost due to inadequate storage facilities may be estimated as food consumption in the household. Another limitation to this method of food security measurement is that the process does not account for differences in individual food consumption but measures total household food consumption (Maxwell 1996).

Maxwell (1996) developed a second method based on 24-hour recalls of food consumption for individual members within the household. After collecting the 24-hour recalls, each food is then analyzed for complete nutrient composition. The advantage of this method over the food stock method described above is that it captures food consumption for individual household members (Maxwell 1996). Limitations to the 24-hour recall method are that it relies on individuals' memory and only accounts for 24 hours, a brief period to estimate food security (Maxwell 1996) accurately. To get an accurate estimate, a researcher may have to do multiple 24-hour recalls, which makes the process expensive to use. Neither the food stock nor the 24-hour recall methods

measure vulnerability or sustainability, which may not lead to a full assessment for food security (Maxwell 1996).

GIS has been used to define and manage food security conditions in Iran (Feizizadeh et al. 2015) and Mexico (Galeana-Pizaña et al. 2018). In the aftermath of the Haiti earthquake, GIS was used to identify extreme damage to critical infrastructure and central regions for eight water and food distribution. Online and mobile GIS platforms allowed distribution networks to visually display areas that had received versus those that had not received food rations and humanitarian assistance (Cruse 2013). The use of GIS by UN organizations such as FAO is becoming widespread. FAO's GIS information is made available through the FAO GeoNetwork powered by GeoNetwork opensource and collectively produced by FAO, WFP, United Nations Environment Programme, and the Office for the Coordination of Humanitarian Affairs (Blanckaert et al. 2004).

Hoddinott & Yohannes (2002) developed a method that relied on linear regression to show an association between dietary diversity and food security. This method was developed by using food consumption data from 10 poor and middle-income countries that were also representative of urban and rural areas (Hoddinott & Yohannes 2002). Low levels of dietary diversity were associated with low levels of food consumption per person and with low caloric availability. An increase in dietary diversity was associated with increased caloric availability from food staples and nonfood staples (Hoddinott & Yohannes 2002). As such, monitoring the dietary diversity of households was determined to shed light on household food security. This method was much simpler and more economical than traditional food security measures that relied on quantitative information (Hoddinott & Yohannes 2002). On the contrary, this method is not validated and has many limitations. (Ruel 2003) explained that for dietary diversity to reflect household food security accurately, Hoddinott & Yohannes (2002) should modify the method to reflect nutrients other than energy and account for portion sizes and frequency of food intake. Additionally, this method needs to have a scoring system, reference periods and cutoff points to classify food security levels (Ruel 2003).

Lorenzana & Mercado (2002) developed and validated a simple method to determine food insecurity in poor urban households. This method consists of qualitative and quantitative components enabling the capture of different dimensions of household food security (Lorenzana & Mercado 2002). The quantitative measure captures the primary energy sources and specific nutrients in a home. In contrast, the qualitative measure gathers information on food intake due to constrained resources and experiences of hunger in the house (Lorenzana & Mercado 2002). The method can be simplified for non-experts in local communities by measuring food diversity instead of measuring predictors of available energy (Lorenzana & Mercado 2002).

The USDA Household Food Security Survey Module (Bickel et al. 2000) shows household food security's qualitative and quantitative dimensions with responses to behavioural and psychological situations. The USDA Household Food Security Survey Module is fit for determining household food security.

2.5 Importance of measuring food security

Food security is a vital universal dimension of household and personal wellbeing. In the 1996 World Food Summit, 186 member states of the UN signed the Declaration of Rome in 1996 pledged their political will to eradicate hunger in all countries and lower the number of undernourished people by half between 1990 and 2015. The sustainable development goals by the UN also highlighted in number 2 the efforts of world leaders and development organizations to achieve zero hunger (all forms of malnutrition) in the world by 2030. The SDG2 commits to universal access to safe, nutritious, and sufficient food at all times of the year globally.

The main aim for measuring food security is to estimate the extent to which individuals have availability, access, utilization, and stability of sufficient safe and nutritious food for active and healthy life (Lele et al. 2016). Therefore, measuring food security is vital to identifying and understanding societal well-being and identifying population subgroups with severe food insecurity conditions (Bickel et al. 2000). Accurate measuring and monitoring of food security

can help public officials, policymakers, service providers, and the public assess and design programs and evaluate existing programs (Babu & Prabuddha 2009; Babu et al. 2014).

Again, accurate food security measurement is crucial to prevent global shocks in the food system. For example, apart from the several causes of the global food price crisis in 2008, such as public policy failure, linkages between biofuel, food and economic markets (Kumar & Quisumbing 2013; Hochman et al. 2014; Tadasse et al. 2016), part of the problem was based on the inability of international agencies and national governments to monitor food security in a sufficiently accurate and timely manner (Headey & Ecker 2013). Therefore, researchers and organizations need to continuously measure the food security status of populations to determine whether residents have optimal food intake and inform the public about risks and possible interventions to food insecurity.

2.6 Pillars of food security

The FAO acknowledges four pillars of food security, including food availability, access, utilization, and stability. Physical food availability addresses the supply side of food security. It is defined as the presence of adequate quantities of food of significant quality, supplied through domestic production, national stock levels and imports, including food aid (Barrett 2001, 2010; Aborisade & Bach 2014). Food access shows the demand aspect of food security (Barrett 2010). Even with adequate food availability at national and international levels, access to food is guaranteed with a policy focus on incomes, prices, and favourable infrastructure (Barrett 2010; Aborisade & Bach 2014). Food utilization defines the ability for individuals and households to make good use of food to which they have access (Barrett 2001, 2010). The food stability component of food security encompasses political stability and economic factors that may impact the food security status (Barrett 2010).

Information on food availability is obtained from national, regional, and subregional food balance sheets (Babu et al. 2014). The FAO food balance sheets determine food availability by

adding foodstuffs produced in a country to the total quantity of food imported and then adjusted to any stock change since the beginning of the reference period. FAO balance sheets do not provide information on consumption patterns and relate only to the supply and availability of food at the national level instead of the household level (Babu & Prabuddha 2009; Babu et al. 2014). Food availability alone does not accurately estimate household or individual food security.

Food access is measured as a combination of physical access determined by access to food in the market and economic access to food at the household level (Babu et al. 2014). Having economic access to food depends on the purchasing power of the household and the status of food prices. Economic access, in turn, depends on physical access to food (Barrett 2001). For example, WFP reported that during the 2008 global food crisis, food insecurity in Nicaragua was principally due to reduced economic access to food compounded by decreased employment opportunities.

Household food access is determined through food or nutrient intake at the household level measured in "adult equivalent" units to compare individuals within a household and different households (Babu et al. 2014). Barrett (2010) highlights that food access denotes problems in responding to shocks such as unemployment spells, price hikes or loss of assets. Because food access is an inherently multidimensional concept that encompasses food markets, infrastructure, and economics, it is a much more difficult pillar to measure than food availability. Surveys that collect information on household composition and household expenditure patterns focusing on food and non-food items, caloric intake, consumption of major products, and socioeconomic characteristics can be used to evaluate food access over time. Food access is estimated from these surveys by determining the amounts of food consumed, the composition of the diet, and nutrient availability at the household and individual level (Babu et al. 2014). The multidimensional nature of food accessibility measurement makes it an expensive and time-consuming tool to estimate household food security. Renzaho & Mellor (2010) explained that access to food does not guarantee household or individual food security unless the food is nutritionally adequate.

Food utilization is assessed by determining feeding practices, food preparation, diet diversity and intra-household distribution of food. Food utilization defines the nutritional status of individuals. It reveals the conversion of consumed food to health and dietary gains of individuals level (Babu et al. 2014). Using this relationship, the quality and quantity of consumed food to achieve energy and nutrient requirements is a primary measure of food utilization level (Babu et al. 2014). Food intake is determined using dietary recalls such as the food record, the 24- hour dietary recall or the food frequency questionnaire. The nutrient composition is determined and compared with the recommended intake of energy and nutrients (Babu et al. 2014).

Food security depends on the stability of the food supply. Weather variability, price fluctuations, political and economic factors can affect the stability of the food supply (UNICEF 2018). The association between food security and political stability at national, regional, and international levels cannot be overlooked. Conflict causes displacement of families, loss of assets, loss of lives and destruction of markets. According to (FAO 2016), conflict can profoundly impact animal health and access to milk, meat, and livestock ownership, directly affecting food security. In addition to conflict, climate change is likely to affect food stability and increase food insecurity. Unlike the access, utilization and availability pillars of food security, there is no known measure of food stability. This may be partly because most conflict and climate events occur spontaneously, allowing for no time for predictions of effects.

2.7 Homegardening and food security

African countries are ranked among the poorest countries in the world, and these countries face chronic poverty and food insecurity. Agriculture (85-90 per cent is rain-fed) in Sub-Saharan Africa accounts for 35% of the region's gross national product (GNP), 40% of exports and 70% of employment (World Bank 2019). Some studies have examined food security in developing countries (Clover 2003; Babatunde et al. 2007). From the analysis of these authors,

improvement in food production in Sub-Saharan Africa will boost per capita GDP and raise purchasing power and food access.

Homegardens contribute to household food security by enhancing food accessibility, availability, and utilization. Homegardens are developed to provide fresh plant and animal food sources in rural and urban regions. Homegardening enhances food and nutritional security in several socio-economic and political situations and improves family health (Mitchell & Hanstad 2004). Homegardens' most fundamental social benefit stems from their direct contributions to household food security by increasing accessibility, availability, and utilization of food products.

Pioneering research on homegardens was conducted by Ochse and Terra in the early 1930s, and the study reveals that homegardens led to 14% of the protein and 18% of the caloric consumption by households in Kutowinangun, Indonesia (Ochse & Terra 1934). Subsequent studies on the Javanese homegardens highlighted a positive association between homegardens and households' nutritional status (Ochse 1937). Homegardening gives opportunity to resource-poor farmers to access food and secondary staples than farmers endowed with more resources (Abebe et al. 2006; Ali et al. 2008). Rural and Peri-urban people obtain their main staple foods from homegarden (Coomes & Ban 2004; Kehlenbeck et al. 2007).

With declining arable land and predicted decline precipitation, the current food security strategies should be rethought (Dai 2013; Vicente-Serrano et al. 2014). Homegardening is a food security strategy that has been promoted for decades in urban, rural, developed and developing communities (Johnson-welch et al. 2000). Homegarden is a small-scale production system located near human dwellings. It has the primary purpose of supplying both plant and animal items that would not otherwise be obtained, affordable or readily available from local markets, field cultivation, hunting, gathering, or fishing (Niñez 1987; Abdoellah et al. 2006).

There are no studies that focus on homegardens in Ghana empirically. However, some studies done by some authors in Ghana can be linked to homegarden and household food security.

Homegarden enhances the food security of rural farmers through available, accessible, and nourishing (Bagson & Naamwintome Beyuo 2012). Container gardening has a significant positive impact on food security, that is, reducing micronutrients deficiencies) in mothers and young children during the lean season in the Northern part of Ghana (Kubuga et al. 2019). Also, In the study done on homegarden and dietary diversity of HIV/AIDS patients in rural households in Ghana, it was concluded that homegarden contributes to food security of HIV/AIDS positive households (Akrofi et al. 2010).

Researchers in other developing countries have documented the relationship between homegardening and household food security. In 2001, the relationship between homegardens and the socio-economic importance in Nicaragua was conducted by (Méndez et al. 2001). The authors discovered that cucurbit and passion fruit were the most important food crops in the homegardens. Forty different plants were used for home consumption, and 25 plants were used for commercial purposes (Méndez et al. 2001). Although Méndez et al. (2001) did not precisely measure food security, their study revealed that farmers in Nicaragua grow homegardens to provide food for home consumption and income generation.

Boone & Taylor (2016) determined whether homegardens has an association\ with food sovereignty in northern Nicaragua. The results revealed that 90% of farmers perceived homegarden as an important contributing factor to diversified and healthy diets while offering an opportunity to save money by not purchasing food from local supermarkets (Boone & Taylor 2016). Arimond et al. (2010) view food availability and food access through production for household consumption as significant pathways by which agricultural interventions influence nutrition. In the Eastern part of South Africa, Selepe & Hendriks (2014) analyzed the impact of homegardens on access to food, nutrient intake, and dietary diversity in pre-school children. Selepe & Hendriks (2014) reported an increased frequency of fresh fruits and vegetable consumption and a doubled increase in the consumption of nuts and legumes by project end. Also, improved dietary diversity representing a direct positive impact of homegardens on food intake was found by (Selepe & Hendriks 2014).

2.8. Determinants of household food security

Several studies investigated the effect of gender of farmers on food security. Mallick & Rafi (2010) examined the food security status of households in Bangladesh. Their results revealed that the gender of the household head did not affect household security. The no gender effect on food security was attributed to no cultural and social restriction on women's participation in labour force. A study by Kassie et al. (2014) assessed how the gender of household heads was associated with food security in Kenya. Their results revealed that female farmers were more vulnerable to food insecurity than male-headed households.

De Cock et al. (2013) analysed farmers' food security issues in rural South Africa, and the analyses indicated that the education of farmers has a positive contribution to their food security. Maitra & Rao (2015) and Abdullah et al. (2019) from India and Pakistan revealed that farmers with a higher educational background are more likely to be food secure than lowly educated farmers.

Another critical determinant of food security is household size. De Cock et al. (2013) estimated the determinants of food security by using multivariate regression analyses. They found that household size was a significant determinant of farmers' food security, and smaller household size was less likely to be food insecure. Kabunga et al. (2014) adopted the Household Food Insecurity Access Scale to measure household food security and found that larger household sizes are associated with higher food insecurity in Kenya. In contrast, the study by Maitra & Rao (2015) in India indicated that a larger household size had less likelihood of being found in a food-insecure category.

In many developing countries, off-farm income is an opportunity to broaden income levels and contribute to farmers' food security. Babatunde & Qaim (2010) analysed the effects of off-farm incomes on food in Nigeria, and the results showed that off-farm income has a favourable impact on farmers' food security. In Northern Ghana, it was found that off-farm jobs significantly affect household food security through improved food consumption (Owusu et al. 2011).

Livestock incomes and ownership are viewed as a vital approach to help minimize food security threats. Dumas et al. (2018) investigated the impact of livestock ownership on food consumption in eastern Zambia. There is a relationship between livestock ownership and dietary diversity among the children in Zambia (Dumas et al. 2018). Mango et al. (2014)] adopted the linear regression to determine the factors of food security among smallholder farmers in Zimbabwe and they found a positive association between livestock ownership and food security.

Headey & Jayne (2014) highlighted that land constraints are relevant in Africa, and that land tenure systems are part of that concern to ensure food security (Rockson et al. 2013). Agricultural land ownership is another factor identified in previous studies associated with food security. For example, Robertson & Pinstrup-Andersen (2010) argued that food security is threatened as the majority of smallholder farmers lack formal users' rights to agricultural land in developing countries. Frelat et al. (2016) stated that farm size has a strong effect on food security in Africa and that farm size increases the probability of a household being food secure.

Agricultural groups are vital institutions and pathways for smallholder farmers to participate in markets, raise incomes, and eventually reduce poverty. The group membership can provide networking and connections that may empower individuals to enhance income generation and nutritional programs to deal with food insecurity issues. Fischer & Qaim (2012)found that members of farmer groups marketed their produce collectively and gained a higher income than non-members who sold individually. A significant impact of active membership on the yield and gross margin of farmers was found in Zambia (Donkor & Hejkrlik 2021).

In terms of access to credit, Aidoo & Tuffour (2015) analysed the factors that affect household food security in rural Ghana. The logistic regression model analysis results showed that credit access had a positive effect on farmers' food security. In Nigeria, it was found that farmers with credit access have higher cassava productivity.

3. Aims of study

Considering issues of poverty and food insecurity in the Northern part of Ghana, it is not clear in terms of the contribution of gardening to food security. This is essential because homegardening has been documented as an integral part of life for the people living in the region. There are limited studies on homegarden in Ghana (Yiridoe & Anchirinah 2005; Bennett-Lartey & Asiedu-Darko 2008; Akrofi et al. 2010).

There is no empirical evidence study on the contribution of homegarden to food security in the region. This study, therefore, seeks to analyze the relationship between homegardening commercialization and their contribution to household food security in the Upper East region of Ghana.

Specifically, the objectives of this study are:

1. To document the level of household income diversification with special regards to contribution from homegardens
2. To estimate the determinants influencing the commercialization of homegardens
3. To quantify the contributions from homegardens to household food security
4. To document the constraints and motivations of local households towards running homegarden.

4. Methodology

4.1 Study site characteristics

The study was conducted in the Upper East region of Ghana, specifically the Bongo and Bolgatanga districts of the region. The region borders Burkina Faso and Togo, and the agroecological zone of the region is Sudan and Guinea Savannah. The climate is of the region is usually hot, with a mean annual temperature of 28.9^{o} C and a unimodal rainfall pattern between May and October. The area is characterized by high rainfall variability (Hulme 2001; Herrmann et al. 2005), making food crop production increasingly insecure (Roncoli et al. 2001). The conditions in the region are typically rural areas in West Africa with low socioecological resilience to climate ecosystem changes.

The region is considered as one of the poorest areas in Ghana and it's characterized by a high illiteracy rate. The Upper East region of Ghana covers 8826 km^2 of the total land area (238,535 km^2) of Ghana (GSS 2012). A greater percentage of the population (80%) was engaged in small-scale rain-fed subsistence farming (GSS 2012). The major crops in the area are maize, sorghum, and millet, which are usually intercropped with groundnut or beans. Vegetables and rice are grown in irrigated areas or rainfed lowlands. The main farming systems are homegardens and bush farms. The homegardens (compound farms) grow primarily for subsistence near the house, while bush farms are cultivated in remote areas where mostly maize is produced. Due to the low capacities for food provision, especially in the dry season, the greater number of people in the Upper East region migrate to southern Ghana in the dry season to find work (van der Gesest et al. 2010)

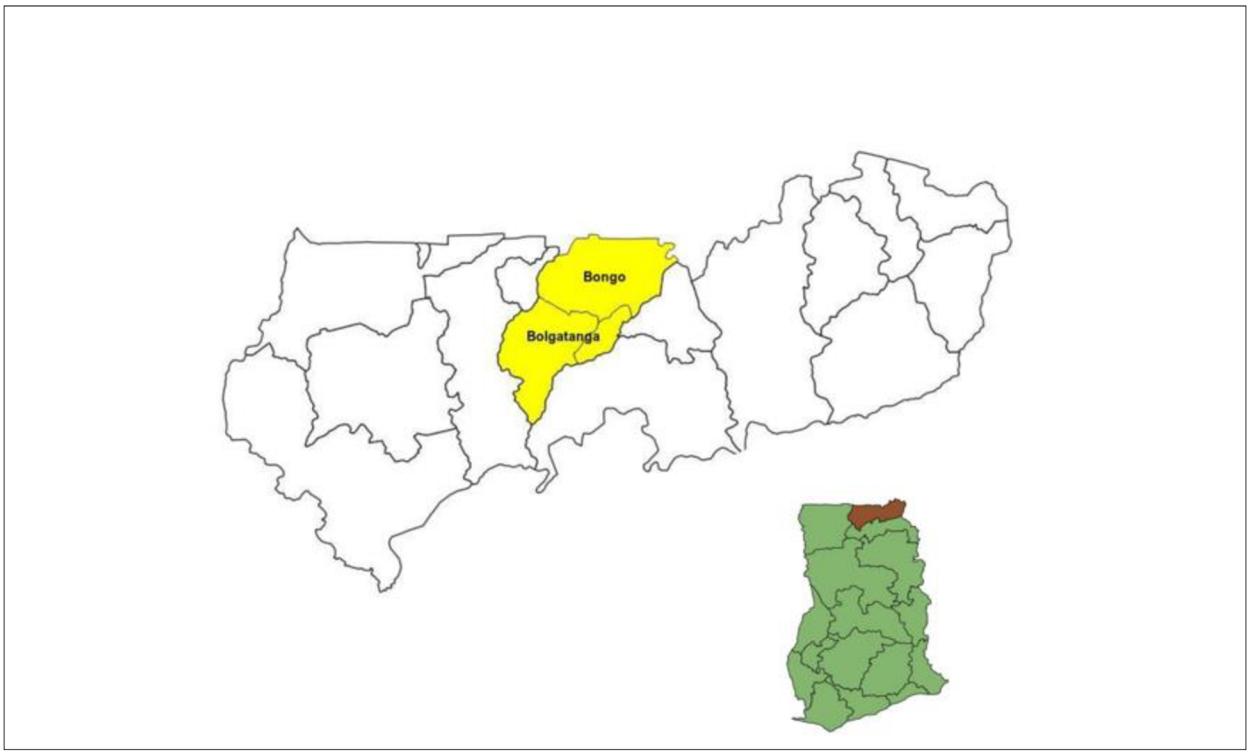

Figure 2. Map of study area

4.2 Data collection

A total number of 120 farmers were interviewed. Non-Probability sampling technique, specifically the purposive technique and snowballing were used to select the homegarden owners for this study (Abebe et al. 2006; Akrofi et al. 2010; Legesse et al. 2016). Data was collected through face-to-face interviews with the farmers through a structured questionnaire. The data of interest was on the social and demographic factors such as age, gender, educational level, farm size, etc. of gardeners that influence food security of the farmers in the Upper East region of Ghana and the level of commercialization by taking inspiration from (Abebe et al. 2006, 2013; Legesse et al. 2016; Whitney et al. 2018; Nkomoki et al. 2019; Abdoellah et al. 2020a).

Data was also collected regarding the food security situation of farmers. Additional data was collected on the production, sales, remittance, and other off-farm income for estimation of homegarden commercialization index and the contribution of homegarden to total household income.

4.3 Description of variables

4.3.1 Dependent variables

The dependent variable for the probit regression model and the selection equation in the linear regression with endogenous treatment effect was homegarden commercialization which was measured as "1" for "high-level commercialization" and "0" for "low-level commercialization".

The outcome variable for this study is household food security which was measured as the Household Food Insecurity Access Scale score.

4.3.2 Independent variables

The independent variables of this study were selected based on a prior review of the literature (von Braun 1995; Vlkova et al. 2011; Whitney et al. 2017; Abdoellah et al. 2020). The independent variables used in all the models of this study were homegarden head's age, homegarden head's gender, homegarden head's years of education, homegarden size, group membership, access to input subsidy, homegarden ownership status, homegarden head involvement in off-farm business, extension access, and water availability.

4.4 Data analysis

Simple descriptive statistics (mean, percentages, and standard deviation) was used to summarize the data similarly used by (Abebe et al. 2006, 2013; Whitney et al. 2018; Abdoellah et al. 2020b). Data on useful crop species was also documented by adopting simple descriptive statistics such as mean, percentages, standard deviation, minimum and maximum.

a. Income diversity and contribution of homegarden to household income

Objective one was analyzed by adopting simple descriptive statistics such as the mean and standard deviation. The contribution of homegarden to household income (HGM/HH) and income diversity of farmers (SDI) was calculated as follows:

$$\frac{HGM}{HH} = \frac{imcome\ from\ homegarden}{total\ household\ income} \quad (1)$$

$$SDI = 1 - \sum_{i=1}^{5}\left(\left(\frac{A}{Ti}\right)^2 + \left(\frac{B}{Ti}\right)^2 + \left(\frac{C}{Ti}\right)^2 + \left(\frac{D}{Ti}\right)^2 + \left(\frac{E}{Ti}\right)^2\right) \quad (2)$$

Where A refers to income from homegarden, B for income from sales of livestock, C for income from salary, D for income from operating a business, E for other income such as engaging in a daily or weekly wage job.

b. Motivation and constraints of operating homegarden

Objective two was captured by using the ordinal scale with 5 as the highest level of perception and 1 as the lowest level of perception. The motivation and constraints of the farmers were depicted with a radar chart.

c. Factors that influence homegarden commercialization

i. Estimation of homegarden commercialization

The level of commercialization of farmers was based on the market orientation of farmers to market. The commercialization was measured as homegarden commercialization index (HCI) by following (von Braun 1995; Abdoellah et al. 2020). Homegarden commercialization index was calculated as the ratio of the value of agricultural sales to the total agricultural production value for each household. Mathematically, HCI was determined as follows:

$$HCI = \frac{Value\ of\ agricultural\ sales}{Total\ value\ of\ agricultural\ production} \quad (3)$$

Based on the homegarden commercialization index, we categorized the farmers into two groups. In this study, the farmers were categorized as "high-level of commercialization" if their homegarden commercialization index is above the average homegarden commercialization index. In contrast, those farmers whose HCI is below the average HCI of the study sample were operationalized as "low-level of commercialization".

ii. Probit regression model

The decision to be a "high-level of commercialization" farmer was modelled under the random utility theory, denoting a farmer as a "high-level of commercialization" based on the utility they receive. Under the assumption of the risk-neutral nature of farmers, their decision to be a "high-level of commercialization" may be influenced by the perceived cost and benefits they will derive from commercialization.

The perceived benefits of "high-level commercialization" can be represented by a latent variable D_J^* expressed as a function of the observed characteristics and attributes, denoted as X in the following latent variable model:

$$D_J^* = X_J\gamma + \varepsilon_J;\ D_J = 1\ if\ D_J^* > 0;\ D_J = 0\ if\ D_J^* \leq 0 \qquad (4)$$

where D_J^* is a dummy variable that equals "1" for "high-level commercialization" and 0 for "low-level of commercialization"; γ represents the estimated parameters. ε is the error term with a mean of zero; X represents the determinants of homegarden commercialization. The binary choice model was estimated with the probit regression model.

d. Impact of homegarden commercialization on food security

i. Estimation of household food security

The food security situation of farmers was measured as household food insecurity access scale (HFIAS) score following (Bickel et al. 2000; Coates et al. 2013). HFIAS is an adaptation of the approach used to determine the prevalence of food insecurity in the United States annually. HFIAS provides insight into the attitude and behaviour of households in the period of the various 'domains' of food insecurity (Bickel et al. 2000). Household experience about food insecurity has shown to be feasible and useful in assessing food security, particularly in developing countries (Bickel et al. 2000; Coates et al. 2013). HFIAS consists of 9 items asked with a recall period of 4 weeks. Respondents will first be asked an occurrence (yes or no) question: if they experienced food insecurity. If the respondent responds as 'yes', then a follow-up question about frequency-of-occurrence (rarely, sometimes, or often) will be asked to determine the severity of the condition. HFIAS score will be expressed as:

$$HFIAS = \text{Q1a} + \text{Q2a} + \text{Q3a} + \text{Q4a} + \text{Q5a} + \text{Q6a} + \text{Q7a} + \text{Q8a} + \text{Q9a} \quad (5)$$

Where, Q1a to Q9a represents the frequency of occurrence questions with a maximum of 3 if the respondent answers yes for the occurrence question and often for the frequency-of-occurrence follow-up question and minimum of 0 if the respondent responds to the occurrence question no. Table 1 below highlights how the HFIAS score is used to determine households' food security situation.

Table 1. HFIAS category

HFIAS food security category	**HFIAS score**
Food secure	0-1
Mildly food insecure	2-8
Moderately food insecure	9-16
Severely food insecure	17-27

ii. Propensity score matching and endogenous treatment regression model

Propensity score matching was used to estimate the influence of homegarden commercialization on the food security of farmers. The propensity score matching algorithm was adopted to control for observable bias associated with the quasi-experimental design (Rosenbaum & Rubin 1983; Wossen et al. 2017). The probit regression model used to estimate the determinants of homegarden commercialization was used to assign propensity scores for both the treatment (high-level commercialization) and the control (low-level commercialization). The farmers who could not find appropriate matches were dropped from estimating the propensity score matching. The impact of homegarden commercialization on the outcome variables (y) was estimated using matched observations. Empirically, ATT is represented as:

$$ATT = E_{P(X)(C=1)}\{\text{E}[\text{y}\ (1)|\text{C} = 1, \text{P(x)}]| - [\text{E}\ \text{y}(0)|\text{C} = 0, \text{P(x)}] \quad (6)$$

where y(1) and y(0) are the outcomes for high-level commercialization and low-level commercialization, respectively, while C=1 for treated (high-level commercialization) and C=0 for control farmers (low-level commercialization). The difference between the two outcomes refers to the treatment effect on the treated (ATT).

The influence of homegarden commercialization on household food security was further analyzed by using linear regression with endogenous treatment regression model by following (Abdoellah et al. 2020). The endogenous treatment regression model was adopted to account for endogeneity and selection bias in estimating the impact of homegarden commercialization on household food security. The endogenous treatment regression model is a linear potential outcome model that allows for a specific correlation structure between the unobserved variables that influence the treatment and the unobservable variables that affect the possible outcomes (StataCorp 2017).

Table 2 below highlights the various variables that were used in the model and their measurement based on previous studies (von Braun 1995; Abebe et al. 2006, 2013; Iglesias-Rios & Mazzoni 2014; Legesse et al. 2016; Kologlu et al. 2018; Nkomoki et al. 2019; Abdoellah et al. 2020).

Table 2. Description and measurement of variables

Variable	Definition	Measurement	Literature source
HMG/HH	Homegarden contribution to household income		
SDI	Income diversity of farmer		
Commercialization	Homegarden commercialization index		(Abdoellah et al. 2020)
Food security	Household food insecurity access scales		
Age	Age of household head	Years	(von Braun 1995; Abebe et al. 2006)
Gender	Gender homegarden head	1 for male, 0 for female	(von Braun 1995; Abebe et al. 2006)
Education	Educational level of homegarden head	Years	(Abebe et al. 2006, 2013; Iglesias-Rios & Mazzoni 2014)
Household size	Size of household	Number	(Kologlu et al. 2018; Nkomoki et al. 2019)
Farm size	Farm size farmer	Ha	(Kologlu et al. 2018; Nkomoki et al. 2019)
Ownership of homegarden	Homegarden head ownership of homegarden	1 for yes, 0 otherwise	(Legesse et al. 2016; Kologlu et al. 2018)
off-farm job	Off-farm job involvement of homegarden head	1 for yes, 0 otherwise	(Legesse et al. 2016; Kologlu et al. 2018)
Input subsidy access	Homegarden head got access to government input subsidy	1 for yes, 0 otherwise	(Legesse et al. 2016; Kologlu et al. 2018)
Water availability	Water is available for usage in homegarden	4-point ranking with 1 as highest and 4 as lowest	(Legesse et al. 2016; Kologlu et al. 2018)
Group membership	Membership in farmer organizations	1 for yes, 0 otherwise	(Kologlu et al. 2018; Nkomoki et al. 2019)
Extension access	Access to extension services	1 for yes, 0 otherwise	(Kologlu et al. 2018; Nkomoki et al. 2019)

5. Results

5.1 Summary of respondents

5.1.1 Household and homegarden characteristics

Table 3 shows the household and homegarden characteristics of farmers in the Upper East region of Ghana. The average age of the farmers suggests that the farmers in the Upper East region of Ghana are within the youthful age bracket (15-45 years). On average, the farmers' have been farming for a longer period (average age of over 13 years). The farmers in the Upper East region operate as smallholder farmers which is common among farmers in developing countries. On average, the farmers have attended at least Ghana's junior high school level of education (over 7 years of education).

The distance from the farmers house to the farm is about 1 km suggesting the homegardens are closer to the house of the farmers. Also, on average, the annual off-farm income of the farmers is about 5000 GHS. The average household size of the farmers is about 4 persons with an average of 1 person as a dependent member and 3 persons as the household labour. The farmers in the Upper East region of Ghana do not get access to agricultural extension agents (average of 1 extension visit per year).

Table 3. Socio-demographic characteristics of farmers

Variable	Pool	High Com	Low Com	Mean Diff
Household age (years)	41.333 (13.159)	40.431 (10.829)	42.177 (15.022)	-1.746
Gender of farmer (Male=1)	82.50%	89.62%	75.80%	13.82
Education (years of schooling)	7.717 (6.309)	7.155 (6.293)	8.241 (6.328)	-1.086
Household size (Number)	4.330 (2.065)	4.396 (1.831)	4.306 (2.236)	0.090
Homegarden size (ha)	0.833 (0.945)	1.145 (1.192)	0.541 (0.484)	0.604***
Ownership of homegarden (Yes-1)	62.50%	67.24%	58.06%	9.18
Off-farm job (Yes-1)	52.50%	53.44%	51.51%	1.93
Input subsidy access (yes=1)	34.20%	32.75%	35.48%	-2.73
Water availability ranking (1=very good,2=good,3=rather poor, 4=very poor)	1.570 (0.618)	1.550 (0.626)	1.580 (0.615)	-0.29
Household labour (Household size minus dependent family members)	3.034 (1.724)	2.862 (1.432)	3.096 (1.799)	-0.234
Extension access (Yes=1)	50.00%	58.60%%	41.93%	16.7*
Group membership (Yes=1)	42.50%	41.37%	43.54%	-2.17
HCI	0.605	0.721 (0.068)	0.496 (0.094)	0.225***

Note P-Values were estimated with T-test at 5% level of probability. *** and * represent 1 % and 10% levels of probability, respectively and standard deviation in parentheses

5.1.2 Useful species cultivated by farmers

Table 4 highlights the most useful crop species cultivated by the farmers in the Upper East region of Ghana. The crop cultivated by majority of the farmers is pepper (45.833%), followed by maize (18.333). The farmers highlighted that they use the main market (Bolga market), middlemen and farmgate to sell their produce after harvesting.

Table 4. Cultivated Species

Species	Scientific names	Farmers growing plant [yes=1] (%)	Parts used	Market used
Alefi	Amaranthus incurvatus Timb.-Lagr. ex Gren. & Godr.	3.333	Leaves	M, MM, FG
Cabbage	Brassica oleracea L.	0.833	Leaves	M, MM, FG
Cowpea	Vigna unguiculata (L.) Walp.	1.667	Seed	M, MM, FG
Garden eggs (Eggplant)	Solanum melongena L.	2.500	Fruit	M, MM, FG
Groudnut	Arachis hypogaea L.	2.500	Seed	M, MM, FG
Guinea corn (Sorghum)	Sorghum sorghum (L.) H.Karst.	0.833	Seed	M, MM, FG
Kenaf	Hibiscus cannabinus L.	9.167	Leaves	M, MM, FG
Lettuce	Lactuca sativa L.	0.833	Leaves	M, MM, FG
Maize	Zea mays L.	18.333	Seed	M, MM, FG
Okra	Abelmoschus esculentus (L.) Moench	0.833	Fruit	M, MM, FG
Onion	Allium cepa L.	12.500	Bulb	M, MM, FG
Pepper (Chilli??)	Capsicum annuum L.	45.833	Fruit	M, MM, FG
Plantain	Musa paradisiaca L. / Musa × paradisiaca	0.833	Fruit	M, MM, FG
Rice	Oryza sativa L.	11.667	Seed	M, MM, FG
Soyabeans	Glycine max (L.) Merr.	5.000	Seed	M, MM, FG
Sweet Potatoes	Ipomoea batatas (L.) Lam.	2.500	Tuber	M, MM, FG
Tomatoes	Solanum lycopersicum L.	13.333	Fruit	M, MM, FG

5.1.3 Food security situation of farmers

From the results, most of the farmers are food secured using household food insecurity access scales (HFIAS). More than 52% of the sampled farmers are food secured, about 42% are within the mildly food insecure and moderate food insecure category, and only few of the farmers are within the extreme food insecurity category (6%).

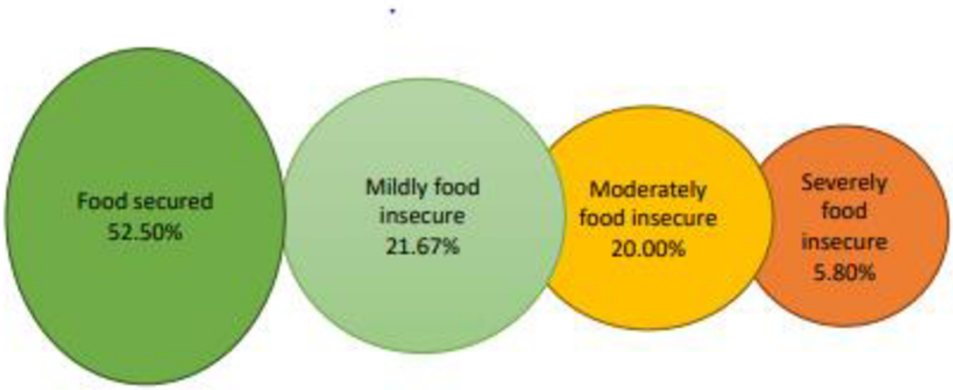

Figure 3. Food security situation of farmers / households

5.2 Income diversity and contribution of homegarden to household income

Income diversification is a crucial livelihood strategy for rural areas, especially in developing countries. From table 5, on average, the farmers depend mostly on homegarden (average income diversity of 0.308). There is no significant difference between the high-level commercialized farmers and the low-level commercialized farmers. Homegarden contributes a greater percentage to the total household income of the farmers in the Upper East region (53.8%). The homegarden contribution to household income for the high-level commercialized farmers (62.6%) was higher than the low-level commercialized farmers (45.4%), and it was statistically significant.

Table 5. Homegarden income contribution and diversity

Variables	(N=120)	High Comm. (N=58)	Low Comm. (N=62)	Mean Diff.
Income diversity (SDI)	0.308 (0.215)	0.303 (0.224)	0.311 (0.207)	0.007
HMG/HH	0.538 (0.343)	0.626 (0.322)	0.454 (0.343)	0.171***

Note P-Values were estimated with T-test at 5% level of probability. *** represents 1 % level of probability and standard deviation in parentheses

5.3 Determinants of homegarden commercialization

Table 6. shows the factors that influence homegarden commercialization. The probit regression estimate shows that older farmers have the lowest propensity to become highly commercialsed than younger farmers. Male farmers are more likely to be highly commercialized than female farmers. Homegarden size strongly influence the level of commercialization of homegarners. In other words, a larger land size increases the probability of a farmers becoming highly commercialized. Farmers who are owners of the homegarden are more likely to be highly commercialized than farmers who are not owners of the homegarden. Farmers who have readily available water have a higher propensity to be highly commercialized.

Table 6. Determinants of homegarden commercialization

Level of commercialization	**Coef.**	**St.Err.**
Age of homegarden head	**-0.040****	**0.016**
Gender	**0.606***	**0.366**
Years of education	-0.003	0.023
Household size	0.058	0.09
Homegarden size	**0.999*****	**0.266**
Ownership of homegarden	**0.479***	**0.267**
Water availability	**0.361***	**0.207**
Off-farm job	-0.227	0.291
Input subsidy access	-0.097	0.298
Extension access	0.419	0.266
Group membership	0.12	0.269
Constant	-0.878	0.719
Number of obs.	120	
P-value	0.001	
LR chi2(11)	30.94	
Pseudo R2	0.195	

***, **, and * represent 1 %, 5% and 10% level of probability, respectively

5.4 Relationship between homegarden commercialization and food security

5.4.1 Propensity score matching estimates

Both the unmatched and the propensity score matching algorithms (nearest neighbour and radius) show that farmers who are highly commercialized are more food secured than the farmers who have a low level of commercialization based on the HFIAS score. The HFIAS score for the high-level commercialization farmers is lower than the low-level commercialization farmers.

Table 7. Propensity score matching estimates for homegarden commercialization and food security

Matching Types	High Commercialization	Low Commercialization	Mean Dif.	Std. Error	Z
Unmatched	2.896	5.919	-3.022	1.003	-3.01***
Nearest Neighbour	2.568	6.313	-3.745	1.585	-2.36**
Radius	3.054	6.006	-2.951	1.394	-2.12**

*** and ** represents 1 % and 5% level of probability, respectively; note, higher HFIAS score represents food insecurity

5.4.2 Linear regression with endogenous treatment effect

The linear regression with endogenous treatment regression estimates confirms that the PSM estimates were affected by hidden bias is statistically significant at 10% probability level). From table 8, a high-level of homegarden commercialization has a significant positive impact on HFIAS score. Of note, a higher HFIAS score represents food insecurity, so the negative influence of high-level homegarden commercialization in table 8 represents the positive impact of high-level homegarden commercialization.

From table 8, other factors also influence food security apart from homegarden commercialization. In this study, male farmers are less food secure (positive influence with HFIAS score). Years of education of a farmer and access to input subsidy contributes positively to food security (negative effect on HFIAS score).

Table 8. Linear regression with endogenous treatment regression estimates for homegarden commercialization and food security

Variables	HFIAS Score	
	Coef.	Std. Erro
Age of homegarden head	-0.049	0.062
Gender	**2.918****	**1.466**
Years of education	**-0.223****	**0.091**
Household size	0.449	0.347
Homegarden size	0.538	0.791
Ownership of homegarden	0.564	1.131
Off-farm job	-0.767	1.158
Input subsidy access	**-2.109***	**1.136**
Extension access	-0.477	1.086
Group membership	0.275	1.046
Water availability		
High commercialization	**-7.991*****	**2.923**
Constant	**8.164*****	**2.696**
/athrho	0.626*	0.377
/lnsigma	1.695***	0.115
Number of obs	120	
P-value	0.004	
LR chi2(11)	27.372	

***, **, and * represent 1 %, 5% and 10% level of probability, respectively

5.5 The Motivation and constraints of homegarden

The greatest motivations for the farmers to operate homegardens in the Upper East region of Ghana are to gain income and contribution of homegarden to food security (figure 4). On the other hand, the farmers suggested that the main constraints of operating homegarden are destruction of the farm by cattle (a common problem in the region), lack of agricultural support, and high initial investment in homegarden (figure 5).

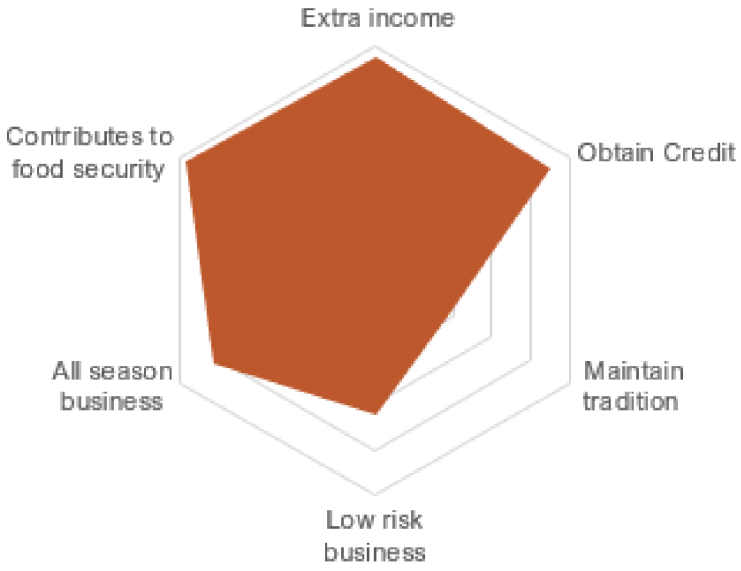

Figure 4. Motivation for operating homegarden

Note: 5-point ordinal scale with 5 as the highest level of perception and 1 as the lowest level of perception

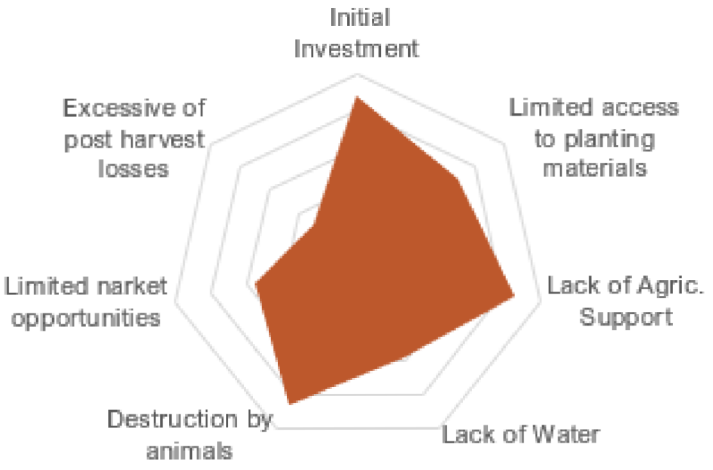

Figure 5. Constraints of operating homegarden

Note: 5-point ordinal scale with 5 as the highest level of perception and 1 as the lowest level of perception

6 Discussion

6.1 Level of household income diversification

It is clear from the results that the farmers depend solely on homegarden for their daily living in terms of food consumption and income generation. The income diversity of the farmers was 0.308 on the average. This means that 70% of the income of the farmers is realized from homegarden. The homegarden contribution to household income was 0.538, suggesting more than half of the income of the farmers is realized from operating homegarden. The results may be linked to the fact that majority of the population in the region depends on agriculture as an occupation (Al-hassan 2015). Similar study was done by Kabir & Webb (2009) and Guuroh et al. (2012) and they found significant impact of homegarden to household income in Bangladesh and Burkina Faso, respectively

6.2 Determinants of homegarden commercialization

The probit regression model showed that older farmers are (0.040) less likely to be highly commercialized. It can be opined that older farmers are less energetic to engage in the activities of highly commercialized farms and may lack the motivation to operate the homegarden as a commercial business. Also, it is common for older farmers to engage in homegarden as a hobby in rural and peri-urban areas, enhancing self-esteem, social engagement, and exercise (Scott et al. 2020). The results of this study is similar to studies such as Tesfay (2020) in Ethiopia.

The results show that the propensity for male farmers to be highly commercialized is higher than for female farmers. The probit model shows that male farmers are 0.606 more likely to sell their production from homegarden than female farmers. Similar result was found in Ghana and India (Yeboah et al. 2021; Dey 2020). This reasons for lower likelihood for female farmers to be highly commercialized can be linked to restrictions in female gender roles (Koenig 2018; Moglia et al. 2020). In rural areas, females may be in the kitchen or take care of the children.

Homegarden size was found to be a significant determinant of the level of commercialization of the farmers. Farmers with larger farm sizes were more (0.99) probable to be commercialized. This could be attributed to larger farm size increasing the potential to produce a higher marketable surplus, hence higher commercialization among farmers with large farm sizes (Bannor & Melkamu 2015). Farmers with smaller farm sizes are less likely to be highly commercialized because the preference to consume their own production is observed as a reason for self-sufficiency objectives (Jaleta et al. 2009). A similar finding was observed in the literature (Fredriksson et al. 2017; Abdullah et al. 2019).

The ownership status of the homegarden has a significant positive relationship with homegarden commercialization. The probit regression model showed that farmers who are owners of the homegarden are 0.479 likely to be highly commercialized. Farmers who are owners of the garden have the freedom to make commercialization decision compared to the non-owners. Homegarden ownership has a predictive influence on making sound agricultural decisions (Mahaliyanaarachchi & Bandara 2010). The findings of this study is consistent with (Mahaliyanaarachchi & Bandara 2010; Yeboah et al. 2021)

Farmers who have ready access to water are more likely (0.361) to be highly commercialized based on the probit regression model. Rainfed agriculture is the most common method of agriculture in developing nations (Food and Agriculture Organization 2021). Extreme weather and climate change have affected farmers' dependency on rainfall, hence the need for sustainable ways to provide water for agricultural purposes (Food and Agriculture Organization 2021). Farmers with ready access to water, such as dams or irrigation, are more likely to increase agricultural production for commercial purposes (Food and Agriculture Organization 2021).

6.3 Household food security and impact of homegarden on food security

The HFIAS analysis showed that the majority of the farmers (52.5%) were food secured, with only 6% of the belonging to the severe food security category. Homegardens contribute to food security by enhancing food accessibility, availability, and utilization. In the Upper West region of Ghana, homegarden enhances rural farmers' food security through available, accessible, and nourishing.

The study results showed that a high-level of commercialization significantly positively affect the food security of farmers. Commercialization of agriculture improves the productivity and competitiveness of smallholder farmers. Agricultural commercialization helps to increase food security and improve household nutrition through increased revenue, providing the necessary cash to buy farming inputs and marketed food (Radchenko & Corral 2018). As a result of commercialization, the farmers may increase their income. It was shown from the results that that the homegarden contribution to household income was about 62.6% of the total income of the farmers. The increases in income could be spent on food and non-food items. The farmers were asked to rank how they used the revenue from the homegarden, and they indicated that, on average, they used about 40% of the total income on food in the household. Similar results were found in Malawi and Vietnam, respectively, by Radchenko & Corral (2018) and Linderhof et al. (2019).

Other factors that were included in the endogenous treatment regression model were statistically significant. The gender of farmer was a significant determinant of food security in this study. The study results revealed that gender has a negative effect on food security, which implies that female farmers are more food insecure than male farmers. The study results are in line with Kassie et al. (2014) study in Kenya and Tibesigwa & Visser (2016) in South Africa. The age of respondents showed a significant positive impact on food security. Similar results relating to age and food security was found by Aidoo & Tuffour (2015) in Ghana, Abdullah et al. (2019) in Pakistan, and Nkomoki et al. (2019) in Zambia. Years of education of farmers has a significant positive impact on food security. Farmers who are highly educated may have other

businesses which could yield additional income and consequently affect food security. Similar results were found by De Cock et al. (2013) and Maitra & Rao (2015) studies in South Africa and India, respectively. As a form of social protection, agricultural input subsidies are often considered an important means of improving agricultural productivity in low- and middle-income countries (Walls et al. 2018)

6.4 Motivation and constraints of operating homegarden

From the results, the most useful crop species by the farmers were maize and pepper. Maize is a major staple and important crop for food security in most African countries (Shiferaw et al. 2011; Langner et al. 2019). Apart from the usage of maize in the household by the farmers, there is also a readily available market for maize in the regional market Bolga. The major motivation for cultivating pepper by the was the availability of the market and higher price of pepper in the study area. Another possible explanation for pepper cultivation can be linked to the irrigation farming system in the study area (Akolgo 2021).

In terms of the motivation with which the farmers operated homegarden, the farmers ranked contribution to household food security and extra income as the highest factors. This result is similar to findings from other countries such as Nicaragua by Méndez et al. (2001) and Boone & Taylor (2016); South Africa by Selepe & Hendriks (2014).

6.5 Suggestions for further research

This study acknowledges that food security could have been measured with other indicators such as the food consumption score and Hunger cores apart from the HFIAS as used by others (Nkomoki et al. 2019). Other dimensions of food security such as availability, utilization and stability should have been captured in addition to the access done by Abdoellah et al. (2020) in Indonesia.

6.6 Recommendation

Based on the results of this study, I recommend that governments and development agencies include and support homegardens in agricultural and rural development policies in Ghana. Since homegarden commercialization affects the food security of the homegardeners, extension agents and development organizations in the Upper East region of Ghana should encourage the homegardeners to commercialize their activities. To encourage the homegardeners to be commercialized, policies that can improve water availability in the area such as dams should be implemented by the government and other NGOs since water availability was significant determinant of homegarden commercialization (Golam Rasul 2016). The government of Ghana's input subsidy program should be encouraged since the results of this study showed a significant impact of access to input subsidy on homegarden commercialization.

6.7 Limitations

This study acknowledges several limitations which may affect the reliability of the results. Firstly, the data was collected with the help of translators since I don't speak the language of the Upper East region of Ghana. There could be the issue of misinterpretation of the questions, which may affect how the respondents answered the questions. Interviewed farmers are not keeping records of their production volumes, and as such, they provided approximate values for the production and income data. The approximate values might not be a true reflection if the farmers had records of activities.

7 Conclusion

Homegardens have become a centre for development initiatives by governments, non-governmental organizations, and development agencies to help in the global challenge of food production and food insecurity, especially in developing countries. This study focused on rural/peri-urban homegardening, its commercialization, the contribution of homegardening to total household income, income diversity, and the farmers' food security situation of the farmers in the Upper East region of Ghana. Specifically, the study sought to document the level of household income diversification with special regards to contribution from homegardens; to estimate the determinants influencing the commercialization of homegardens, to quantify the contributions from homegardens to household food security and to document the constraints and motivations of local households towards running homegardens

Mixed sampling technique was used to select 120 farmers who were running homegardens. Commercialization was calculated using the homegarden commercialization index, which categorized the homegardens into more and less market-oriented (high and low commercialization levels). Food security was measured via HFIAS Score. We estimated the income diversity of the farmers and the contribution of homegarden to total household income. Probit regression was used to analyze the factors that influence commercialization level of the farmers. Also, the propensity score matching, and endogenous treatment regression model were used to analyze the impact of homegarden commercialization on the food security of the farmers.

The study revealed that 52.5% were food secured according to the HFIAS score. The income diversity of the farmers was 0.308 on average. The homegarden contribution to household income was 0.538.

The probit regression model showed that the age of homegarden head, gender, homegarden size, ownership status of homegarden, and water availability significantly affects homegarden commercialization.

The results further showed that homegarden commercialization significantly contributes to farmers' food security in the Upper East region. Other factors that influenced the food security of the farmers were gender, years of education, and access to input subsidy.

The findings from the motivation of operating homegarden highlighted the important role of homegardens in food security and gaining additional income. Major constraints for operating homegarden were high initial investment capital, lack of agricultural extension service or support, and destruction of the garden by animals.

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Appendix

a. Questionnaire for study

Questionnaire for contribution of homegarden to food security and Agrobiodiversity in the Northern Ghana

Section 1: Household characteristics

Please fill the following information as clearly as possible

1. Name of home-gardener.....
2. Village or city of home-gardener.....
3. Gender of home-gardener.....
4. Age of home-gardener.....
5. Years of education of home-gardener.....
6. Years of farm experience of home-gardener.....
7. Number of members of household.....?
8. Did you receive remittance (money transfer from relatives? Yes ( ) No ( )

9. Characteristics of household members

Names of people who live together with you in a household	Age (Years)	Years of education	Working on-farm	Working off-farm	Estimate the time they participate on the farm

Section 2: Farm characteristics

10. How many times did you meet an extension agent in the last year.....?
11. What is the size of your agricultural landholding (Ha).....?
12. What is the size of your farm (Ha).....?
13. Do you have off-farm business/activity? Yes ( ) No ( )

Section 3: Institutional Characteristics

14. Did you get access to credit in the last year of farming operations? Yes ( ) No ( )
15. Did you get access to input subsidy in the last year of farming operations? Yes ( ) No ( )
16. Are you a member of farmer organization or cooperative? Yes ( ) No ( )

Section 4: Cost of Household

17. Please estimate annual cash expenditure (GHS) from last year (2020) related to the following activities listed in the table

Farm	**Household**	**Health care**	**Education**	**Paying back for credit**	**Other**
(Fertilizer, seeds, fuel, fodder, farm equipment, etc.)	(Electricity, energy, firewood, water, land, house repair, transport)				(government taxes, gifts to temples, etc.)

18. Please estimate your cash income GHS from last year (2020) from the activities listed below. If you have no income from the listed activity write down zero (0)

Farm	**Livestock**	**Off-farm job**	**Regular wage**	**Money from relatives/friends**	**If other, please specify**
(Rice, soybean, groundnut, etc.)		(own business, shop, restaurant, etc.)			(government pension, etc.)

Section 5: Household Food Security

19. Please fill the following table as it applies to the situation in your household

NO	QUESTION	RESPONSE OPTIONS	CODE
1.	In the past four weeks, did you worry that your household would not have enough food?	0 = No (skip to Q2) 1=Yes	….|___|
1.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….|___|

2.	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	0 = No (skip to Q3) 1=Yes	….|___|
2.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….|___|
3.	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	0 = No (skip to Q4) 1 = Yes	….|___|
3.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….|___|
4.	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to	0 = No (skip to Q5) 1 = Yes	….|___|
	obtain other types of food?		
4.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks)	….| |

		3 = Often (more than ten times in the past four weeks)	
5.	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	0 = No (skip to Q6) 1 = Yes	….| |
5.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….| |
6.	In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?	0 = No (skip to Q7) 1 = Yes	….| |
6.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….| |

7.	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	0 = No (skip to Q8) 1 = Yes	….| |
7.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….| |
8.	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	0 = No (skip to Q9) 1 = Yes	….| |
8.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….| |
9.	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	0 = No (questionnaire is finished) 1 = Yes	….| |

9.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….| |

Section 6. Crop species planted in your home-garden

Species name	**Number of individuals**	**Period of cultivation (harvest)**	**What do you use this species for**	**Who is the final consumer of this species**	**Who decided to grow this species**	**If the specie is grown for the market, indicate the selling place**	**Quantity harvested last season**
	Individuals	Y-years M-months C-cultivation H-harvest	A-food B-Medicine C-construction D-food for animals E-firewood F-other, specify	M-market H-household in %	M-market F-family N-neighbors G-government	M-market H-home/middlemen	KG
