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Determinants of Tanzania Rural Households' Income Diversification and its Impact on Food security

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Dedication

I dedicate this work to my parents for their endless sacrifices. You have always supported me no matter the situation I found myself. Asanteni sana

To my friends, classmates and mentors who shared their words of advice and encouragement to finish this project.

And lastly, I dedicate this work to the Almighty God, for the protection, power of mind, skills, and strength to endure in challenging times.

Abstract

The purpose of this study is to analyze the determinants of rural household income diversification and its impact on food security in Tanzania. With the current changes in the climatic conditions, there is a need for households to reduce their dependence on agriculture and diversify into other income generating activities. Apart from climatic shocks, I study what other factors influence the level of income diversification in Tanzania rural households Data from the National Panel survey covering 2251 households for 2010/11 and 2012/13 were used, forming a long-balanced panel of 4502 households. A Tobit regression model is applied to determine factors influencing household income diversification. Results of descriptive statistics show that value of household productive asset, household size, climatic shock, household's education level, and age are important determinants of household income diversification. Rich households obtain the largest share of their income from wages (35%) while poor households obtain the largest share from crop sales (61.7%)

To examine the impact of Income diversification on household food security, binary logistic models are used. The results show that income diversification increases household calorie intake. Meaning that a household with more diversified income consumes more calories per day per adult. However, increasing income sources does not affect household food spending because agriculture supply a large share of their food requirements.

Since households rely on rain-fed agriculture as their main source of income, there is a need for diversification in order to increase their income and improve their food security status.

Therefore, policies should be set to encourage households to diversify their income into non-farm activities as it is necessary for sustainable income and improved health.

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Abbreviations

FAO: Food and Agriculture Organization of the United Nations

IHI: Inverse Herfindahl Index

Kcal: Kilocalorie

OLS: Ordinary Least Square

URT: United Republic of Tanzania

WHO: World Health Organization of the United Nations

1 Introduction

As it is with most developing countries, agriculture remains the main source of food and income for Tanzania Rural households. It contributes up to 29 percent of the GDP, 24 percent of exports and employs about 75 percent of the livelihood including the majority of the poor in rural areas.

However, due to low productivity, adverse climatic changes and increasing population, the sector has not been able to solve the household level malnutrition and food insecurity. The sector has experienced a growth rate of 4.4 percent, slower than the overall economic growth rate at 7 percent (URT, 2014).

Food security and agriculture are closely linked as rural households solely depend on food crop production and livestock for survival. Therefore, minor variations in climatic conditions can have a significant impact on households' food security status.

Agriculture development continues to be an important aspect in the fight against poverty and food insecurity, however as countries face adverse climatic conditions which affect agricultural production, the non-agriculture sector plays an important role in reducing food insecurity (Babatunde and Qaim, 2010). As a result, households in developing countries are increasing their income from multiple income sources, moving away from the traditional view that they are mainly peasants who specialize in farming to obtain their income.

A household diversifies its income when it allocates its productive resources among different income generating activities. The diversification can be within the farm by for example growing different crops, rearing different kinds of animals, working in the farm or other farm-related activities (Abdulai and CroleRees, 2001; Loison and Bignebat, 2017). A household may also diversify into non-farm activities by engaging in waged labor, business like local shops, sales of handcraft and labor migration.

Income diversification among households is considered an efficient means to ensure sustainable income and hence improve food security within the household. It can also be used as a strategy to secure survival, minimize risk or reduce income variability.

According to FAO, there is an increase in the absolute number of people facing chronic food deprivation from 804 million in 2014 to 821 million in 2017. The situation is far worse in Africa with almost 21 percent of the population undernourished (FAO, 2018).

At the household level, food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food to meet their dietary need and food preferences for a healthy and active life (FAO, 1996).

Several studies have been conducted to study the patterns, determinants, and impacts of income diversification on households' livelihood in Sub- Sahara Africa (Abdulai and CroleRees, 2001; Babatunde and Qaim, 2009, 2010; Owusu et al., 2011; Gautam and Andersen, 2016; Loison and Bignebat, 2017)

Most of the conducted studies have shown a significantly positive impact of income diversification on total household income. Barrett et al. (2001) showed that highly income diversified households had higher wealth and income in Cote d'Ivoire and Kenya. The same

was observed in Ethiopia by Block and Webb (2001) who reported that a higher level of income diversification was associated with higher welfare.
However, a higher total household income resulting from different sources does not necessarily convert to food security within the household. This is because households may spend such income on other goods and services such as school fees and housing. Thus, a household with more income might still be food insecure.
Therefore, this study aims to study the determinants of income diversification and its impact on household food security.

1.1 Problem statement

As stated by Djurfeldt (2014), although rural households rely on agriculture as their main source of income, they still obtain a large share of their income from non-farm activities, thus, increasing household wealth and ensuring food security. It is possible that encouraging households to diversify their income could improve their livelihood and food security status.
The extent of diversification at the household level is determined by several factors such as changes in the climatic condition, education, household access to credit, household assets and many others.
The change in climatic conditions may force households to adapt new agricultural systems as well as other non-farm activities. Adoption of diverse income generating activities may generate enough income for households to meet their food requirements. This will contribute to the United Nations Sustainable Development Goal (SDG) number 2 (Zero Hunger) by studying how income diversification can be used as a means to improve household food security. This thesis will also investigate how households respond to climatic disasters such as floods and droughts in term of their economic activities.
In Tanzania, not much attention has been given on the impact of diversification on food security. This is confirmed by the inadequate availability of empirical studies that specifically investigate income diversification and food security among rural households.

1.2 Objective

Based on the National Panel Survey conducted by the National Bureau of Statistics, this study seeks to examine the determinants of income diversification among households and how income diversification impacts food security. Specifically, the study answers the following questions:

i. What are the determinants of income diversification in the household?
ii. Does a high income diversification in the household leads to increased food security?

1.3 Delimitations

The study uses the National Panel Survey conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank through the Living Standard Measurement Study-Integrated Survey on Agriculture (LSMS-ISA) program.
The data covers a wide range of topics including agricultural production, non-farm income generating activities, consumption expenditure, and many other socio-economic activities.
As a result, most of the income generating activities are aggregated into six main groups and this aggregation may not reveal the exact source of such income.
Further on, due to difficulties in measuring food security, the study only measures two dimensions of food security; food access and food utilization through food expenditure and calorie intake indices respectively.
The data were collected in four rounds, 2008/09, 2010/11, 2012/13 and, 2014/15. However, due to a large number of missing values the first round (2008/09) is not used in this study, the fourth round (2014/15) was refreshed covering different households and therefore was also dropped.
From the four rounds of the survey waves, 2010/11 and 2012/13 are used for this study.

1.4 Structure of the study

The remaining part of the paper is organized as follows. The second chapter deals with a review of literature on income diversification, determinants and food security in developing countries. The third chapter deals with a description of the research methodology used which include data source, method of analysis and econometrics model specification. The results of the study are discussed in chapter four. Finally, conclusion and policy recommendation of the study are presented in chapter five.

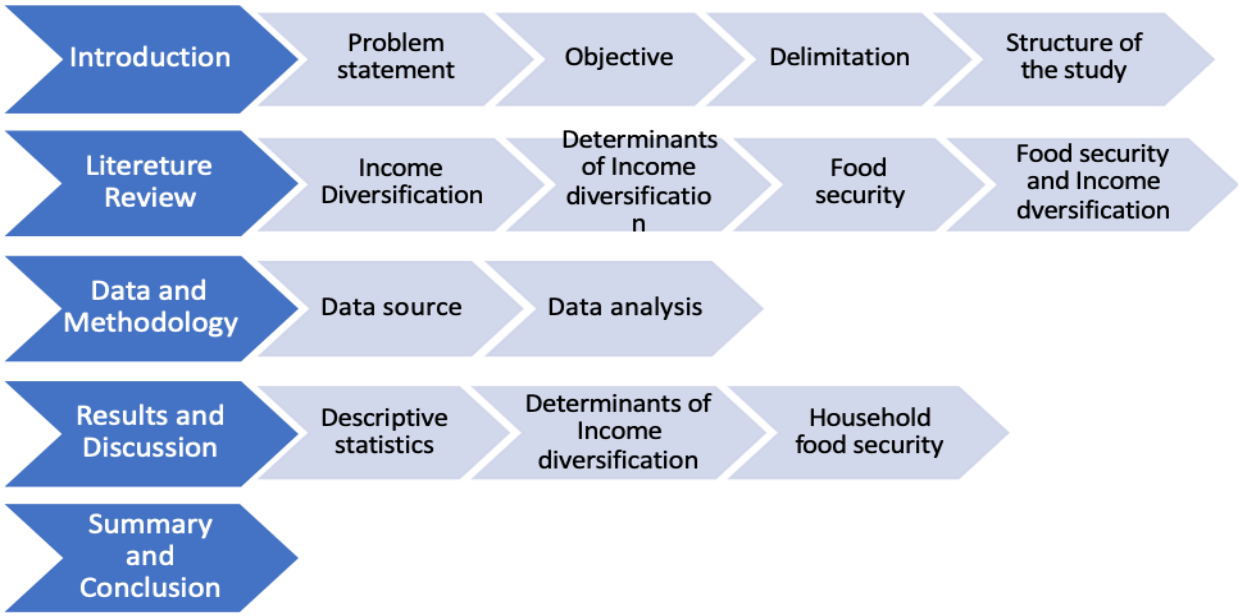

Figure 1: Structure of the study

2 Literature review

This section reviews the literature from earlier studies conducted in the field of income diversification and food security in Sub Sahara Africa. It presents an overview of the concept and determinants of income diversification, food security and the relationship between food security and income diversification.

2.1 Income diversification

There is a traditional view that the rural economy in Sub-Saharan Africa is mainly formed by farmers with their livelihood solely depending on Agriculture. However, substantial evidence shows that households diversify their livelihood into multiple activities to sustain their day to day needs (Djurfeldt, 2014)

Income diversification is a strategy whereby productive assets are allocated among different income generating activities (Abdulai and CroleRees, 2001)

There is no single agreed definition of diversification, Joshi et al. (2002) and Ersado (2003) define diversification as the increase in the number of income sources or the balance among the income sources. A household with two income sources with equal contribution is therefore considered more diversified than a household with two income sources but one source contributing 90 percent of the total income.

Diversification can be of the whole rural economy or for individual households. Rural economy diversification means a total sectoral shift from farm economy, that is primary agricultural production to the non-farm economy which is income generating activities other than agriculture, for example; mining, commerce, and transport. Household diversification is when households increase their number of income-generating activities from different sectors and locations. It can be farm or non-farm activities, on-farm or off-farm activities and wage employment or self-employment (Babatunde and Qaim, 2009; Loison, 2015; Loison and Bignebat, 2017). Reardon (2001) define non-farm activities as activities which are undertaken outside agriculture including own-farming and wage employment in agriculture. The on-farm/off-farm distinction reflects the spatial distribution while the farm/non-farm reflects the sectoral classification derived from national accounting practices (Barrett et al., 2001).

A considerable amount of research has been conducted to study income diversification and welfare in rural Sub- Saharan Africa as covered by Loison (2015). These studies explain the increase in the importance of non-farm and off-farm income on rural household wellbeing. Although different methodologies have been used, most studies have found diversification to have a significant role in increasing household welfare and reducing income inequality and poverty. Loison (2015) found that many households have diversified their livelihood through non-farm activities and migration. The author also found that income diversification is among the strategies that characterize the rural economy and have a substantial contribution to their welfare with about 35% of the households' total income generated from non-farm sources.

Barrett, Reardon, and Webb (2001) argue that a lot of households do not generate their income from a single source, hold all their wealth in a form of a single asset or use their asset

in only one activity. Their study found that non-farm income account for as much as 40-45% of the average household income. Haggblade et al. (2001) also found that about 42% of rural households' income is generated from non-farm activities while Hoang et al. (2014)) found that 50% of the household income is generated from other sources than from farming.

A review of the literature on rural livelihood diversification shows that there is a positive relationship between non-farm income and household welfare characteristics such as income, wealth, consumption and nutrition. Using household survey panel data, Hoang et al. (2014) concluded that diversification into non-farm activities can be a significant instrument for poverty alleviation.
Apart from its contribution to household income and welfare, participating in non-agricultural activities help households to overcome credit constraints and reduce risks as they are able to generate extra income apart from agriculture. This goes back to improving farm production and aid in smoothing consumption.
Income diversification can, therefore, be thought of as a means to increase household consumption and as a pathway out of poverty for rural households.

Most of the studies on diversification in Sub-Saharan Africa (Babatunde and Qaim, 2010, 2009; Loison and Bignebat, 2017; Owusu et al., 2011) have been based on cross-sectional data for particular countries and hence do not capture the long term effect of diversification on households. Since not so many studies have employed the use of panel data there is a need for empirical evidence to capture the dynamics of rural diversification.

2.2 Determinants of income diversification

There are different reasons as to why diversification takes place both at the micro and macro level. Barrett and Reardon (2000) mention risk reduction, diminishing return to factor use in agriculture, response to a crisis, a realization of economies of scale and liquidity constraint as some of the factors determining diversification at the micro level. At the aggregate level of households, specialization according to competitive advantage and scarcity of productive assets leads to diversification.
Several other studies have investigated what factors influence income diversification in developing countries. Babatunde and Qaim (2009), Barrett et al. (2001) and Hoang et al. (2014) discovered that not all households have equal motive and opportunity to engage in non-farm activities and earn extra income. Risk reduction could be one of the reasons as to why households diversify their income, in that regard households give up expected returns in exchange for reduced income variability. Therefore, those with lower income are more risk averse and hence are expected to diversify more than those with higher income. However, it was found that poorer households are less diversified than richer households. This is because poorer households are more likely to face entry barriers to participate in nonfarm activities which require skilled labor, relatively high level of education and large investments.
Therefore, risk mitigation cannot explain the widespread of rural diversification in Sub-Saharan Africa and as a result, this study follows that of Abdulai and CroleRees (2001) by investigating factors of income diversification.

Barrett et al. (2001) and Loison and Bignebat (2017) classify the factors inducing households to diversification as push factors and pull factors. The pull factors are risk reduction, high transaction costs, reaction to crises, response to diminishing factor returns in agriculture like labor in the presence of land constraints, and pull factors are specialization, proximity to urban areas and improved infrastructure systems.
By using data from 220 households in Nigeria, Babatunde and Qaim (2009) identified household education level as one of the determinants of diversification. Employing the number of income sources as a measure of diversification they found that an additional year of schooling increased the number of income sources by 0.024. This is because education facilitates access to different economic activities, either as a formal requirement to higher paying jobs or helps in starting and running a business. Barrett et al. (2001) had similar findings in Uganda, where those with primary and higher education had a higher likelihood of participating in nonfarm activities than those without any education.

The shrinking farm sizes per capita coupled with the increasing population growth is another factor forcing households to engage in non-farm activities. Small farm sizes lead to labor surplus in the agriculture sector, thus a household will apply some labor to their own farm and lend some labor out for off-farm wage payment or self-employment in other sectors (Reardon and Berrett, 2000). Since factors of production face diminishing returns to scale, the household will employ the number of resources that maximize output in the farm and use the rest in other economic activities. However, Babatunde and Qaim (2009) found no significant effect of farm size on diversification in Nigeria.

Loison (2015) point out that diversification is also facilitated by the development of infrastructural structures like tarred roads and electricity, the emergence of rural towns and improved accessibility to urban areas. Apart from increasing physical access to markets and improving non-farm earning opportunities, this opens up new opportunities previously inaccessible to rural households. Households with access to local markets are more likely to participate in non-food production activities than those in remote areas. Barrett, et al. (2001) argue that it might be difficult to distinguish fixed effects associated with agroecological, cultural, historical, and other spatial attributes form market access effects.

Lack of complete insurance and credit markets compels households to diversify their income as a means to protect themselves against substantial income fluctuation. It also implies that households cannot smooth their consumption in spite of the desire to do so. Since insurance markets are highly incomplete in rural Sub-Saharan Africa, risk-averse households lack the option to purchase insurance to secure themselves against income risk, instead they turn to diversification as a means of risk reduction. Also, access to financial services like credit is hampered by weak legal systems which fail to penalize defaulters. In the case where households are able to secure credits, it reduces liquidity constraints as it supplies households with enough capital to venture into non-farm businesses which normally involves substantial capital requirements (e.g., transport niche) (Reardon, 2000).
Loison (2015) suggests that increased public expenditure on infrastructure, the emergence of modern technologies, promoting of agricultural marketing and agribusiness will reduce rural

Sub-Saharan Africa households' reliance on agriculture and hence increase participation in other non-farming activities.

2.3 Food security

Food security may have different meaning depending on the context. There are a lot of definitions and indicators of household food security as was found by Hoddinott (1999). The FAO defines food security as "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life".
Food security can be termed at different levels, that is, global, regional, local, household and individual level. The FAO argues that food insecurity is more prominent at the regional and local level due to poor infrastructure which hinders the distribution of food from surplus areas.

Food security is also divided into three main dimensions; availability, access and utilization.
At the macro level, food availability explains the physical existence of food at a national level at a particular point in time. It includes domestic production, domestic stocks, commercial imports, food aid and other supply indicators (FAO, 2002 and Aidoo et al., 2013)
Access entails both at the economic and physical level. Economic access covers the range of food choices available to the household given their income level and prevailing food price. Physical access covers the nature and quality of logistic infrastructures like ports, roads, railways, communication, food storage facilities and other installations that facilitate the functioning of markets. Also, a household can have access to food from their own stock, purchases in the marketplace or transfer from the community, government and foreign donors.
Food utilization determines the use of food in the household. Whether the food they can afford meets the nutritional requirements or choose to consume nutritional inferior diet. Therefore, utilization deals with the quality in terms of essential minerals and vitamins as well as safety and sanitary condition of the food. In addressing food security as much as food availability and access are important, utilization should also be considered as the quantity of food does not necessarily convert to well-nourishment (Barrett et al., 2010)

Tanzania, like many other developing countries, has a large rural population built on agriculture and other agriculture-related activities as their primary source of income and food. This heavy reliance on agriculture for food production coupled with the current climate change implies households more prone to food insecurity as they are not able to produce enough food to meet households demand.
According to the Tanzania National Bureau of Statistics, about 39 percent of the population suffers from undernourishment and 33 percent have low average dietary energy intake.

The country is characterized by regional disparities in different dimensions such as resource endowment, agro-climate, population density and uneven economic and agricultural development among various regions. As a result, food security status varies from one region to another and from one season to another. Highland regions of Mbeya, Iringa, Njombe, and

Ruvuma have more favorable climatic conditions and hence more food secure. However, the semi-arid central regions of Dodoma and Singida and some parts of Shinyanga, Morogoro, Kigoma, and Mara are less food secured due to unfavorable climatic conditions (URT, 2016).
At the national level, the country is food sufficient with a Food Security sufficiency ratio (FSSR) of 138 percent in 2011/112. This does not translate to food security at the individuals and household level as Ecker et al. (2011) found that approximately 30% of the population of mainland Tanzania was unable to meet their basic food requirements due to poverty. Also, Haug and Hella (2013) found that about 45% of the rural population lacked sufficient food energy at the individual level.
Agricultural production, therefore, ensures that enough food is available for the household to consume. However, since food security is multidimensional in nature, agricultural production alone is not enough to ensuring food security as doing that lead to an overreliance on domestic agricultural solutions (Webb et al., 2010; URT, 2016).

2.4 Food security and income diversification

Food insecurity is intrinsically linked to poverty and increasing household income and the number of income sources could be one of the solutions to improve food security within a household.
A considerable number of studies have established a relationship between diversification, higher income and consumption over time (Reardon et al., 1992; Hussein and Nelson, 1998; Block and Webb, 2001; Okwoche and Asogwa, 2012).
Panel data have been used to study non-farm activities in Sub-Saharan Africa and found that non-farm diversification results in more rapid growth of income and consumption. Diversification into non-farm income generating activities has been used as a source of income from which households generate income, build assets and use that to purchase food (Loison, 2015).
Owusu et al. (2011) found that non-farm income is crucial in the fight against food insecurity and poverty in Ghana, they concluded that non-farm income has a positive and statistically significant effect on household income and food security. This is because off-farm economic activities are used as a coping strategy that provides rural households with additional income.
It also enhances the households' economy and food security by reducing dependency on agriculture and hence supplying additional income and decreasing food deficit when agricultural production falls short.

However, studies have also found that diversification does not have the same benefit to all rural households as the poorer are left behind due to low literacy and lack of capital to invest in non-agricultural activities. It is also not clear whether diversification will improve the living standard of people in Sub-Saharan Africa since most of the studies are based on cross-sectional data and therefore do not capture the long term impact of diversification (Abdulai and CroleRees, 2001; Hoang et al., 2014; Loison, 2015).

Most of the studies have concentrated on the impact of income diversification on household welfare. With the globe facing climatic changes together with the need to eradicate poverty

and hunger by 2030, it would be interesting to see what factors influence income diversification and how that impact the households' food security. Also, very few studies have studied the impact of income diversification on household food security and no such study has been conducted in Tanzania.

Taking advantage of newly available data from the National Panel Survey, this thesis seeks to examine the determinants of income diversification among rural households in Tanzania and how this diversification affects the household food security status.

3 Data and methodology

The methodology used in this study is presented here. The section includes an overview of the data source and the analytical techniques used to achieve the specific objectives.

3.1 Data source

The data for this study is the National Panel Survey which was conducted by Tanzania National Bureau of Statistics in collaboration with Ministry of Finance and Planning, Poverty Eradication Division, European Commission, Bill and Melinda Gates, UNICEF and Millennium Challenge Account (MCA-T). This study employs two rounds of the surveys conducted in 2010/11 and 2012/13. The National Panel Surveys were implemented with the assistance from the World Bank through the Living Standard Measurement Study-Integrated Survey on Agriculture (LSMS-ISA) program.
The National Panel Survey is a national level longitudinal survey aimed at collecting information on agricultural production, non-farm income generating activities, consumption expenditure, and other socio-economic households' characteristics.

3.2 Data analysis

Data is analyzed by using the Tobit and logistic regression models as well as descriptive statistics. Income diversification is measured by the Herfindahl index while food security is measured by food expenditure and food security indices.

3.2.1 Determinants of income diversification in the household

Different methods can be used to measure income diversification among households as discussed by Culaset et al. (2005) and Minot et al. (2006). Babatunde and Qaim (2009), Loison and Bignebat (2017) and many have used the inverse Herfindahl Index.
Herfindahl index originates from the industrial organization literature where it used to measure the degree of industry concentration. It can also be used to measure the degree of concentration of income from various sources at the individual household level.
Since we are interested in diversification, which is the reverse of concentration, we use the inverse Herfindahl Index (IHI).
The IHI has the advantage of estimating both the number of household income sources and the contribution of each income source to the total household income (Zhao and Barry, 2013). The IHI ranges from one (household is highly specialized with complete dependence on a single income source) to the maximum possible value (highly diversified). It rises with the increasing number of income sources when all income sources are equally distributed.

The IHI is expressed as below

$$IHI = \frac{1}{Herfindal\ Index} = \frac{1}{\sum_{i=0}^{n} {S_i}^2} \qquad (1)$$

$S_i =$ the share of income source i in total income
$n =$ the total number of income sources

The total household income is disaggregated into 6 categories: Crop income, Livestock income, Wage income (agricultural and non-agricultural wage income), Self-employed income, Remittance income, and other income.

Empirical model

The Censored Tobit regression model is used to identify the factors which determine a household's income diversification. This is because a large number of households obtain their income from a single source of income and hence the dependent variable (IHI) ranges from a lower limit of one to the maximum possible number. Application of the OLS, in this case, results in biased and inconsistent estimates of the parameters (Maddala, 1983, 1986).

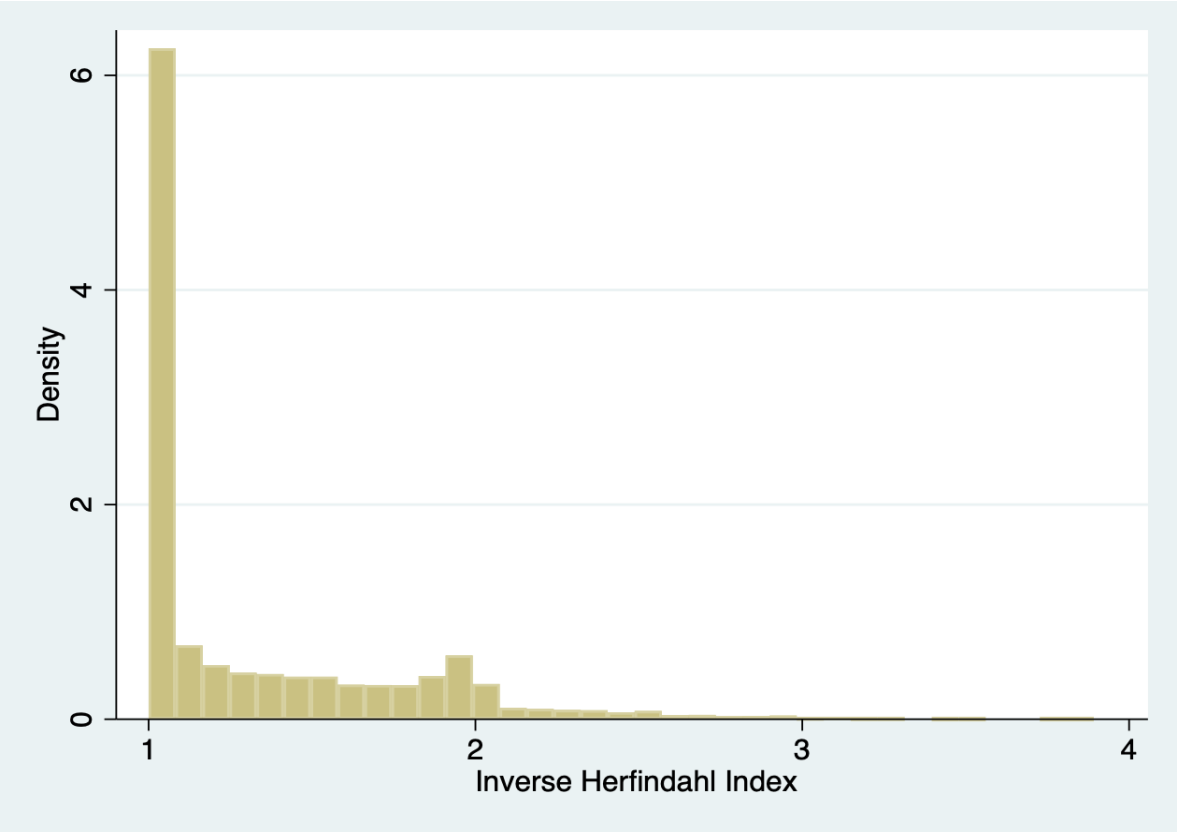

Figure 2: Distribution of the Inverse Herfindahl Index

The model supposes that there is a latent (i.e. unobservable) variableIHI^*_{it}. This variable linearly depends on a set of explanatory variables X_{it} via a vector A, which determines the relationship between explanatory variables X_{it} and the latent variableIHI^*_{it}.

To examine the determinants of income diversification while accounting for many one values, I set up the following latent regression model:

$IHI^*_{it} = AX_{it} + B_i + C_t + \delta_{it}$ *(2)*

$IHI_{it} = IHI^*_{it}$ if $IHI^*_{it} \geq 1$, $IHI_{it} = 0$ otherwise

Where:
IHI^*_{it} = Latent (unobserved) for income diversification
IHI_{it} = Dependent variable for income diversification
X_{it} = Vector of explanatory variables
B_i = Household fixed effect
C_t = Year fixed effect
A = Vector of parameters to be estimated
δ_{it} = Random error term

Explanatory variables

The most commonly used explanatory variables of income diversification in previous literature are household characteristics like age, education, gender of household head, household size, and marital status. Other variables include access to credit, access to electricity, farm size, household assets, and climatic condition.

Climatic shock: This is a dummy variable that assumes the value of 1 if a household had experienced drought or flood in the past five years. Households which experienced drought or floods are expected to diversify their income sources into multiple sources as a natural response to such shocks

Age of the household head: The age of the household head may determine how many income activities the household is involved in. Older household heads have accumulated a wealth of experience in different areas and hence can be involved in multiple activities. It can be the case that older household head may lack the energy and ability to be involved in multiple activities and hence specialize in only one income generating activity.

Sex of household head: Gender of the household head is included as a dummy variable which takes the value of 1 if a household is headed by male or 0 if headed by a female. Since the household head is responsible for supporting the household economically, male-headed households are expected to diversify more than female-headed households due to the difference in gender roles in rural areas. Most women in rural areas are involved in farming and do not participate in other non-farm activities compared to men.

Education level: Household's head education level is an important determinant in the level of diversification in the households. The variable is categorized into three, household head with no formal education, with primary school level education and with secondary or higher education level. Findings by Barrett et al. (2001) and Babatunde and Qaim (2009) shows that education has a positive and significant impact on household income diversification.

Education open new opportunities for individuals to diversify their income. Therefore, education is a key variable in studying the determinants of diversification in rural households.

Access to electricity: Access to electricity will reduce the household's reliance on agriculture as they can invest in electricity productive uses such as agricultural processing and processing of wood and metal products. It is expected that access to electricity associate positively with household income diversification. The variable assumes the value of 1 if the household has access to electricity and 0 if the household has no access to electricity.

Table 1: A prior expectation of variables used in the Inverse Herfindahl Index model

Variable	Description	Measurement	prior sign
age	Age of the household head	years	+/-
Gender	Gender of the household head	1 = male 0 = female	+
Married	Marital status of the household head	0 = Single 1 = married 2= otherwise	+/-
Educ	Education level of the household head	0 = Illiterate 1 = Primary 2 = Secondary/Higher	+/-
electr	Household access to electricity	1 = Yes 0 = No	+
credit	Household access to credit	1 = Yes 0 = No	+
hhsize	Household size	Number of individuals in the household	+/-
Farm_size	Farm size	Number of acres	+/-
Farm_assset	Value of productive assets owned by the household	Tanzania Shillings	+
Climatic_shock	Households affected by drought or flood (past 5 years)	1 = Yes 0 = No	+/-

Household size: this is measured by the number of members within the households. A large household size provides enough labor to be used both on the farm as well as in other non-farm activities such as waged labor and self-employment. Hence larger households are expected to diversify more.

Household farm size: This is the total amount of farm size owned by the household and is measured in terms of acres. It implies the amount of land available for agricultural production as well as for rent to other households. Reardon and Berrett (2000) argue that smaller

household farm sizes leave households with excess labor which is then used in other income-generating activities. However, Babatunde and Qaim (2009) found no significant impact of farm size on the level of income diversification. This variable is expressed in log form since some households own no land at all while some own up to 274 acres of land. The log form expression of the variable account for outliers.

Household head marital status: this variable controls for the different categories of marital status of the household head. In this study, a household head is single, married or otherwise (widowed, divorced or separated). Married households are expected to diversify more due to higher labor endowment compared to single, divorced or widowed households.

Value of household productive assets (farm assets): Households with more valued assets are expected to diversify more compared to those with less valued assets. Assets such as tractors can be used by the household as collaterals to obtain a loan which can be invested in other income generating activities apart from agriculture. Due to the difference in the value of assets owned among households, this variable is expressed in log form in order to normalize the data.

Household access to credit: Households with access to credit are expected to diversify more since they have the resources required to invest in different income generating activities. Sources of credit include commercial banks, micro-finance banks as well as neighbors and friends. As a result of having access to credit, households can invest in businesses which they previously could not due to lack of enough capital (Reardon, 2000). Access to credit takes the value of 1 if a household has access to credit and 0 if the household has no access to credit.

3.2.2 Household food security

To measure household food security, two food security indices are constructed. One based on household food expenditure relative to the total expenditure and the second based on the household calorie intake per adult per day.

Household food security based on household food expenditure

The first food security index will be constructed by using the expenditure method of Omotesho et al. (2016), Omonona and Agoi (2007) and Arene (2011). This will classify the households into either food secure or food insecure.
A household is food secure if its per-capita monthly food expenditure is above or equal to two-thirds of the mean per-capita food expenditure, while a food insecure household is that whose per-capita monthly food expenditure falls below two-thirds of the mean monthly per-capita food expenditure.

$$F_i = \frac{\text{per capita food expenditure for the ith household}}{\frac{2}{3}\,\text{mean per capita food expenditure of all households}}$$

f_i = Food security status of the households which take values 1 for a food secure household and 0 for a food insecure household.

$$f_i = \begin{cases} 1 \; if \; F_i > 1 \\ 0 \; otherwise \end{cases}$$

The implicit form of the model is specified as:

$$f_{it} = aIHI_{it} + bX_{it} + c_i + d_t + e_{it} \qquad (3)$$

$where$:
f_{it} = Household food security status
IHI_{it} = Inverse Herfindahl index
a = coefficient of Inverse Herfindahl index
X_{it}= Household characteristics
c_i = Household fixed effect
d_t = Year fixed effect
e_{it} = Error term

Household food security based on food consumption in the last 7 days

Since Tanzania faces nutrition challenges related to undernourishment with high rates of protein-energy deficiency MAFAP (2013), the second food security index defines the minimum level of nutrition necessary to maintain healthy living. This measures the household food access and consumption derived from seven days recall per household.
The food security line is the recommended daily per capita calorie intake of 2360 kcal (WHO, 2007). I convert all the food items consumed by the household in the 7 days period to nutrient values by using the corresponding values from the Tanzania Food Composition table. Total household per capita calorie intake is divided by household size (adjusted to adult equivalent)[1]. To obtain household's daily per capita calorie intake I divide the household daily per capita calorie intake by seven.

A household with a daily per capita calorie intake above or equal to 2360 kcal is regarded as food secure and those below 2360 kcal are regarded as food insecure

$$Ei = \frac{\text{Daily per capita calorie intake for the ith individual}(Xi)}{\text{Recommended calorie intake (2360 kcal)}(R)}$$

e_i = Food security status of the households which adopts values 1 for food secure households (Xi/R≥1) and 0 for food insecure household (Xi/R<1).

Based on the household security index e_i the binary logistic model is estimated to identify the impact of income diversification and other socio-economic variables on daily per capita calorie consumption:

$$e_{it} = \alpha IHI_{it} + \beta X_{it} + v_i + z_t + u_{it} \qquad (4)$$

[1] Normalized household size to adjust for the difference in food consumption and nutrition requirement among household members. It is assumed that children and the elderly consume less than working-age adults.

Where:
Ei = Food security status for the ith household
IHI_{it} = Inverse Herfindahl index used to measure income diversification
Xi = Household characteristics
α = IHI parameter to be estimated
$\beta = Vector\ of\ household\ characteristcs$ parameters to be estimated
v_i = Household fixed effect
z_t = Year fixed effect
u_{it} = Error term

Logistic regression model

Binary logistic regression models are used to determine the impact of income diversification on household food security (that is, equations 3 and 4).
A logistic regression model is a type of regression where the dependent variable is categorical. It could be binary or multinomial; in the latter case, the dependent variable of multinomial logit could either be ordered or unordered. Since the food security indices constructed above are binary where one represents food secure and zero represents food insecure, a binary logit model is used in this study.

Therefore, the conditional probability $\Pr(f_{it} = 1|IHI_{it})$ and $\Pr(e_{it} = 1|IHI_{it})$ measures the probability of a household being food secure given their income diversification index. a, b β and α are the coefficients of the logistic model from which the marginal effects are derived. The marginal effect measures the conditional probability $\Pr(f_{it} = 1|IHI_{it})$ and $\Pr(e_{it} = 1|IHI_{it})$ when there is a unit change in the coefficient.
The parameters of the logistic regression models are estimated with the Maximum Likelihood Estimation (MLE) technique.

Since income diversification is not random among households, it is likely that the independent variable (IHI) is endogenous. Also, there might potentially be a reverse causality problem, this is because food security at household level might influence household labor productivity and participation in different economic activities. This leads to inconsistencies in the estimated coefficients.
To correct for endogeneity in the model, I employ the control function approach (Petrin and Train, 2010). This involves the following steps

i. Regress the income diversification index on its explanatory variables
ii. Predict the residuals
iii. Include the residuals, the endogenous variable (IHI) together with other explanatory variables in the structural model
iv. If the residuals are significant then income diversification index (IHI) is endogenous and the residuals are left to be part of the structural model
v. If the residuals are not significant, the residuals are removed from the structural model

4 Results and discussion

This study is based on the two waves of the national household panel survey conducted in 2010/11 and 2012/13 involving 3,924 and 5010 households respectively. Since the focus of this study is on rural households, urban households are dropped from the sample. This leaves 2,550 households for the 2010/11 survey and 2290 for the 2012/13 survey. Of these, 39 households that were in the 2010/11 survey did not participate in 2012/13. Another 299 households were new entrants in the 2012/13 survey, leading to a total of 338 households being excluded from the sample of rural of rural households. This left a sample size of 4502 rural households which was used for analysis in a balanced panel.

4.1 Descriptive statistics

This section presents the summary statistics of socio-economic characteristics of the household and household head[2] as well as the description of the household income sources and composition.

4.1.1 Socio-economic characteristics

The results show that the age of the household head ranged between 18 and 107 years with an average of 49.09 years. The distribution of age is normally distributed implying that most of the household heads are in their working years and hence can be involved in multiple economic activities.
Gender of the household head can also influence whether the household increases its sources of income. Of the 4,502 households analyzed, only 1,071 households (23.79%) were headed by women while 76.21 percent (3,431) were headed by men.

Household heads in a formal marriage represented 64.28 percent of the sample while 35.72 percent represented household heads who were single, divorced, widowed and those who were unmarried but living together at the time the survey was conducted.

The education level of the household head was categorized into three, those who had no formal education (illiterate), those with primary level education and finally those with secondary, diploma or university level education. Although illiteracy is expected to be high in rural areas this study found that only 28.79 percent of households' head were illiterate, while 59.86 percent had primary education and the remaining 11.35 percent had a secondary school, college or university level education.

As most rural households depend on agriculture, farm size is one of the most important variables as it directly affects their food production as well as income. Households with larger

[2] The adult person, male or female, who is responsible for the organization and care of the household or who is regarded as such by the members of the household

farm sizes can produce more food compared to those with small or no farms. From the study, the average farm size is 5.5 acres with some households having no access to land at all.

The size of the household determines whether the households get involved in multiple income-generating activities. Larger households are more likely to diversify as they have more labor at their disposal compared to a household with only one member. On average the study found the household size to be about 6 people with the smallest and largest household having 1 and 55 members respectively.

The results also show that many of the households do not have access to national grid electricity with only 9.51 percent with access. Access to credit is almost equally shared with 54.2 percent of the household in a position to access credit from micro-finance institutions, commercial banks as well as neighbor and friends.

Value of household productive assets such as tractors, seed planters, and threshers are important in determining the extent of diversification within the households as such assets can be used to generate income apart from agriculture. For example, a household can use their tractor as collateral to secure loans which can be invested in other income generating activities apart from agriculture. To account for outliers since some households did not own any productive assets, the variable is expressed in log form.

Table 2. Summary statistics

	(1)	(2)	(3)	(4)	(5)
VARIABLES	N	mean	sd	min	max
Gender (Household Head)	4,502	0.762	0.426	0	1
Marital status (Household Head)	4,495	1.320	0.501	0	2
Household size	4,502	5.767	3.249	1	55
Access to electricity	4,502	0.0951	0.293	0	1
Access to credit	4,502	0.542	0.498	0	1
Log household farm size	4,014	1.248	1.059	-4	5.613
Climatic shock	4,502	0.282	0.450	0	1
Log household productive assets	4,002	10.740	2.039	0	19.887
Age (Household Head)	4,502	49.09	15.74	18	107
Education (Household Head)	4,502	0.826	0.609	0	2

Source: Own computation from the surveys

4.1.2 Household Income sources and composition

Rural households earn their income from multiple sources like farming, wage labor, construction labor, local shops, sales of fish, animal products and handicrafts, other employment or migration. In this study households' income sources were classified into six categories; Crop income, Livestock income, Wage income (agricultural and non-agricultural wage income,) self-employed income, remittance income, and other income.

The results from table 3 show that the majority of households (63.93%) earn their income from agricultural activities with crop production having the highest contribution at 50.12

percent and livestock keeping at 13.81 percent. Agricultural income was generated from the sale of crops, sale of livestock and related products.

Table 3: Household income sources composition

Quartile	Other Income	Wages	Self employment	Remittance	Crop sales	Livestock sales
1	0.1869	1.5672	15.5216	1.4586	61.7332	19.5325
2	0.2851	4.4506	20.2411	0.9305	61.0143	13.0784
3	0.8674	10.8783	23.5003	0.9110	51.0884	12.7546
4	3.0049	35.2319	15.0538	1.1032	32.7187	12.8876
Total	1.2212	14.7547	19.0439	1.0468	50.1204	13.8131

Source: Own computation from the surveys

The large share of agriculture in the total household income supports the claim that rural households in Tanzania depend on agriculture as their main source of income. Apart from agriculture, households also obtain a large share of their income from self-employment at 19.04 percent.

Table 4. Households' head education and income composition

Education	Other Income	Wages	Self-employment	Remittance	Crop sales	Livestock sales
Illiterate	0.6871	9.3022	21.8174	0.7824	52.0662	15.3447
Primary school	1.3164	9.6771	19.3503	0.9738	54.4691	14.2133
Secondary/higher	2.0407	58.2636	10.1339	2.1501	19.8599	7.5518
Total	1.2212	14.7547	19.0439	1.0468	50.1204	13.8131

Source: Own computation from the surveys

Although agriculture have the largest share in the total household income, there exists a difference between rich and poor households as well as educated and non-educated. Results in table 4 show that households headed by highly educated individuals rely more on non-farm income (wages) while households headed by individuals with no formal education rely on agriculture (crop sales). The income quartiles in Table 3 reveals that the richest households (quartile 4) obtain the largest share of their income from wages at 35% while the poorest households (quartile 1) obtain the largest share of their income from crop sales at 61.7 %. This implies that wealthier and educated households are engaged in non-farm activities while the illiterate and poor households generate the largest share of their income from agriculture.
The share of income from self-employment is almost the same between the richest and the poorest households with 15.05% and 15.52% respectively.
Remittance and other income sources have the smallest share in the total household income with 1.05% and 1.22% respectively.

4.2 Determinants of income diversification

In this study, income diversification refers to the number of income sources a household has. The Inverse Herfindahl index (IHI) described in Chapter 3 is used as the dependent variable. The IHI of one means that the household is specialized in only one economic activity and as the IHI moves away from one, the more diversified the household income is.

Table 5: Determinants of income diversification

	(1)		(2)	
VARIABLES	Coefficients		Coefficients	
Male (H/Head)	0.0412		0.0470	
	(0.0379)		(0.0378)	
Marital status (H/Head) = 1, Married	0.0356		0.0398	
	(0.111)		(0.110)	
Marital status (H/Head) = 2, Otherwise	0.0790		0.0854	
	(0.110)		(0.110)	
Age (H/Head)	-0.00229**		-0.00215**	
	(0.000911)		(0.000907)	
Education (H/Head) = 1, Primary	0.0916***		0.0853***	
	(0.0308)		(0.0306)	
Education (H/Head) = 2, secondary/higher	-0.100*		-0.108*	
	(0.0587)		(0.0584)	
Access to electricity	0.00662		0.00618	
	(0.0649)		(0.0646)	
Access to credit	0.0234		0.248***	
	(0.0221)		(0.0546)	
Household size	0.00516		0.00518	
	(0.00431)		(0.00429)	
Climatic shock	0.0777***		0.0735***	
	(0.0256)		(0.0255)	
Log farm size	0.0883***		0.0846***	
	(0.0143)		(0.0143)	
Log productive asset	0.0377***		0.0369***	
	(0.00731)		(0.00728)	
sigma_u		0.312***		0.310***
		(0.0207)		(0.0207)
sigma_e		0.579***		0.577***
		(0.0128)		(0.0128)
Year fixed effects	NO	NO	YES	YES
Constant	0.529***		0.289**	
	(0.135)		(0.145)	
Observations	3,543	3,543	3,543	3,543
Number of households	1,949	1,949	1,949	1,949

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Rural households in Tanzania generate their income from more than one source with the average Inverse Herfindahl Index of 1.32.

The results presented in table 5 shows that the age of the household head, education level, value of productive assets, farm size and climatic shock are significantly different from zero at 1%, 5% and 10%.

Age of the household head was found to be negative and significant at a 5% significance level. This means that the older the household head is the less they diversify. Other factors kept constant, a one-year increase in age of the household head decreases diversification by 0.002 points. This might be due to the fact that as the household head gets older they lack the physical strength and ability to be involved in multiple income generating activities.

Education of the household head at primary level showed a positive significant impact at 1% level of significance while education at secondary or higher level showed a negative and significant impact at 10%. Household heads with primary school education had more diversified income compared to household heads with no formal education. However, education at secondary and university level had a negative and significant impact at 10% significance level. Household head with a secondary or higher education level had a 0.1 lower diversification compared to those with no formal education. This means that households headed by highly educated people have less diversified income. This could be explained by the fact that as one gains higher education they obtain specialized skills and hence more likely to engage in nonfarm high paying salaried employment. This is consistent with the finding of Abdulai and CroleRees (2001) who found that lack of formal education act as a barrier preventing households from engaging in nonfarm income generating activities.

Farm size owned by the household was found to be positive and significant at 1% level of significance. The results show that, for every 1% increase in the farm size, there is a 0.0008 unit increase in the income diversification index. This means that all other things unchanged, the larger the farm size the more a household's income is diversified. This suggests that larger farm sizes allow households to undertake large agricultural production the income of which can be invested in other income generating activities. This finding contradicts that of Loison (2015) where the author found that declining farm sizes in Sub Saharan Africa has pushed households to diversify into non-farm activities.

Households which experienced climatic shocks in terms of flood or drought in the past five years had 0.0777 units higher diversification index compared to those which had no such climatic shock. This coefficient was positive and significant at 1% level of significance. It is highly likely that diversification was used by households as a natural response to occurrence of droughts and floods.

It is expected that a household with more productive assets will engage in diverse income generating activities. From our results, the value of productive assets owned by the household shows a positive and significant impact at 1% level of significance. Everything else constant, an increase in the household's productive asset by 1% leads to 0.0004 units increase in the household income diversification index. In rural areas, productive assets such as tractors can be used in other activities such as transport of crops from farms and hence act as an extra income source for the household. Also, household productive assets facilitate entry into both farm and non-farm activities as they can be used as collateral in case a household intends to

obtain a loan that could be used to start a business. As stated by Barrett, Reardon and Webb (2001) richer households have more freedom and diversify into lucrative activities while the poor face an entry barrier. These findings support that of Agyeman et al. (2014) and Babatunde and Qaim (2009)
The gender of the household head, marital status, access to electricity, access to credit and household size were positive, however, they had no significant impact on household income diversification.

4.3 Household food security status

This section presents the regression results of the logistic model used to measure the impact of income diversification on household food security. As explained in chapter 3, the Inverse Herfindahl index is used to measure the household level of diversification while food security is measured by two indices, one based on household food expenditure and the other based on calorie intake per adult per day.
Since the dependent variables are binary, the logistic regression model is used for the estimation. The coefficients from the logit model have no economic interpretation, so the marginal effect is estimated at the mean of the sample. The marginal effects show the change in probability when the independent variable change by one unit.

4.3.1 Household food security based on household food expenditure

The household food expenditure index measures the status of household food security by looking at the household food expenditure in relation to the total household expenditure. Households with food expenditure lower than the two third mean of the total expenditure were considered as food insecure while those above were considered as food security.

Table 6 below presents the marginal effects of the regression model obtained after running the logit regression model.
The result shows that age of household head, access to credit, household size, productive assets, and farm size have a significant impact on the household food security status at 5% level significance while the Inverse Herfindahl index is insignificant.

Surprisingly, the Inverse Herfindahl Index exerts a positive however insignificant impact on household food security. By measuring household food security based on food expenditure, income diversification does not improve household food security, therefore, having more income sources do not increase household food expenditure. This can be attributed to the fact that households obtain more than 63% of their total income from the sale of crop and livestock products, this means that households produce enough agricultural products to sell as well as feed the household. Hence the lower spending on food is due to the fact that farming provides most of the household's food requirements. This contradicts with the findings by Babatunde and Qaim (2009), Abdulai et al. (2011) and Loison (2017) who found that adopting income diversification is crucial for improving rural households' food security status considering the risky nature of farming in rural areas.

Table 6: Food security (food expenditure) coefficients

VARIABLES	(1) Coefficients		(2) Marginal effects	(3) Coefficients		(4) Marginal effects
Inverse Herfindahl Index	0.131		0.0253	0.123		0.0237
	(0.0907)		(0.0174)	(0.0914)		(0.0175)
Male (H/Head)	-0.00950		-0.00183	0.0471		0.00902
	(0.118)		(0.0227)	(0.131)		(0.0251)
Marital status (H/Head) = 1, Married	-0.193		-0.0371	-0.146		-0.0280
	(0.335)		(0.0643)	(0.339)		(0.0652)
Marital status (H/Head) = 2, Otherwise	-0.310		-0.0596	-0.213		-0.0410
	(0.331)		(0.0636)	(0.348)		(0.0668)
Age (H/Head)	-0.00713**		-0.00137**	-0.00920**		-0.00176**
	(0.00282)		(0.000539)	(0.00366)		(0.000698)
Education (H/Head) = 1, Primary	0.00135		0.000259	0.0851		0.0163
	(0.0956)		(0.0184)	(0.136)		(0.0259)
Education (H/Head) = 2, secondary/higher	0.265		0.0511	0.141		0.0270
	(0.180)		(0.0347)	(0.218)		(0.0420)
Access to electricity	0.352*		0.0676*	0.353*		0.0676*
	(0.210)		(0.0403)	(0.211)		(0.0403)
Access to credit	0.300***		0.0577***	0.806**		0.154**
	(0.0780)		(0.0148)	(0.355)		(0.0675)
Household size	-0.441***		-0.0847***	-0.435***		-0.0835***
	(0.0242)		(0.00291)	(0.0252)		(0.00327)
Log farm size	0.178***		0.0342***	0.267**		0.0511**
	(0.0460)		(0.00874)	(0.107)		(0.0204)
Log productive asset	0.123***		0.0236***	0.162***		0.0310***
	(0.0252)		(0.00471)	(0.0489)		(0.00925)
Year fixed effect	NO		NO	YES		YES
lnsig2u		-1.428**			-1.394**	
		(0.621)			(0.605)	
Constant	0.909**			0.980*		
	(0.420)			(0.561)		
Observations	3,543	3,543	3,543	3,543	3,543	3,543
Number of households	1,949	1,949		1,949	1,949	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

A dummy variable was used to measure household access to credit, the results show that household access to credit has a positive significant effect on the household food security status. At a 1% significance level and controlling for year fixed effects, households with access to credit increase their probability of being food secure by 15 percentage points compared to those with no access to credit. Access to credit can enable a household to invest in different income generating activities and hence earn more income which can be used to purchase food for the household.

The household size exhibited a negative significant impact on the household food security meaning that households with fewer household members were more food secured than those with more household members. On average one less member in the household increases the probability of the household food security status by 8.4 percentage points.
Farm size and value of productive assets also had a significant impact at a 1% level of significance. The results show that, on average, a one percent increase in the household farm size increases the household food security status by 0.034 percentage points while a one percentage increase in the value of the household productive asset increases its food security status by 0.031 percentage points.

4.3.2 Household food security based on calorie intake

This food security index measures the individual households' members calorie intake based on food consumed in the last 7 day. Households with individual calorie intake per day per adult equivalent (Kcal/AE/Day) below the recommended calorie intake of 2360 Kcal/AE/Day were regarded as food insecure and those above were regarded as food secure. In this analysis, the Inverse Herfindahl Index was included in the regression to measure how income diversification affect household food security
The descriptive shows that the average calorie intake was 2459 Kcal/AE/Day, slightly higher than the recommended daily intake of 2360Kcal/AE.

Since the dependent variable is binary as in the food expenditure method, a logistic regression model was also used in this section. The marginal effects are used in the interpretation of the results.
From column 2 and 4 in table 7 below, it is observed that the Inverse Herfindahl Index, education of household head, access to electricity, household size, and productive assets are significant at 1% level while the age of household head is significant at 5% level of significance. Household head marital status, gender of the household head, is significant at a 5% level of significance. The coefficients of gender, marital status, and farm size are not statistically significant.

Table 7: Food security (calorie intake) coefficients

VARIABLES	(1) Coefficients		(2) Marginal effects	(3) Coefficients		(4) Marginal effects
Inverse Herfindahl Index	0.291***		0.0438***	0.288***		0.0431***
	(0.105)		(0.0158)	(0.106)		(0.0158)
Male(H/Head)	0.0134		0.00202	0.210		0.0314
	(0.156)		(0.0236)	(0.169)		(0.0252)
Marital status (H/Head) = 1, Married	-0.389		-0.0598	-0.235		-0.0353
	(0.393)		(0.0611)	(0.385)		(0.0583)
Marital status (H/Head) = 2, Otherwise	-0.441		-0.0677	-0.107		-0.0162
	(0.395)		(0.0615)	(0.394)		(0.0597)
Age (Household Head)	0.00921**		0.00139**	0.00165		0.000246
	(0.00391)		(0.000586)	(0.00454)		(0.000679)
Education (H/Head) = 1, Primary	0.374***		0.0561***	0.691***		0.102***
	(0.139)		(0.0207)	(0.172)		(0.0245)
Education (H/Head) = 2, secondary/higher	1.330***		0.207***	0.908***		0.136***
	(0.237)		(0.0368)	(0.269)		(0.0425)
Access to electricity	1.689***		0.255***	1.693***		0.253***
	(0.254)		(0.0365)	(0.255)		(0.0363)
Access to credit	0.196**		0.0295**	1.539***		0.230***
	(0.0921)		(0.0138)	(0.440)		(0.0647)
Household size	0.400***		0.0603***	0.426***		0.0637***
	(0.0268)		(0.00306)	(0.0287)		(0.00323)
Log farm size	0.0424		0.00639	0.368***		0.0551***
	(0.0887)		(0.0134)	(0.136)		(0.0202)
Log productive asset	0.193***		0.0290***	0.336***		0.0502***
	(0.0429)		(0.00638)	(0.0634)		(0.00922)
residual	-0.445		-0.0671	3.414**		0.511**
	(0.756)		(0.114)	(1.435)		(0.213)
lnsig2u		0.139			0.170	
		(0.226)			(0.223)	
Year fixed effect	NO			YES		
Constant	-6.421***			-5.716***		
	(0.676)			(0.707)		
Observations	3,543	3,543	3,543	3,543	3,543	3,543
Number of households	1,949	1,949		1,949	1,949	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

These results suggest that participation in more than one income generating activities is associated with higher calorie intake per adult per day. Households with more diversified income have higher calorie intake compared to those with less diversified income. This might be due to the fact that multiple income sources provide a household with enough income to purchase food that meets their dietary requirements. From the marginal effect in column 4, on average, one unit increase in the Inverse Herfindahl index increases household's calorie intake above the recommended amount (2360Kcal) by 4.31 percentage points. This result supports that of Babatunde and Qaim (2010) who found that households with off-farm income consumed more calorie per day per adult.

A household with access to electricity exhibited the marginal effects of 0.253, 0.06 marginal effect for household size, 0.05 for household assets and household's head education was 0.102 marginal effect for those with primary school education and 0.136 for those with secondary or higher education level. This implies that, on average, a household with access to electricity is 25 percentage points more likely to consume more calories above the recommended level (2360Kcal) than those with no access to electricity. For household heads with secondary education or above, individuals in the household are 13.6 percentage points more likely to consume more calorie above the requirement compared to those household headed by an individual with no formal education.

Column 4 in both table 6 and table 7 represents the marginal effect of the logistic regressions controlling for yearly macroeconomic variables between the survey in 2010/11 and the survey conducted in 2012/13. As can be seen, the marginal effects are significant without controlling for year fixed effects (column 2) and with year fixed effects (column 4). This means that there were no significant variables that affected households differently between the years.

5 Summary and Conclusions

In this study, I analyze the determinants of rural household income diversification in Tanzania and how it affects household food security. Two years National Panel survey data from 2010/11 and 2012/13 were used in the analysis forming a balanced long panel of 4502 households.

A Tobit regression model was used to estimate the determinants of income diversification while logit regression models were used to analyze the impact of income diversification on household food security.

The findings show that rural households have moderate diversified income with an average diversification index of 1.32. Income from crop sales and livestock sales account for the largest share of household income with 50.12% and 13.81 % respectively, making a total of 63.93 %.

There was no change in the trend of the agriculture sectors between 2010 and 2013 as it maintained the contribution to total income both at 50%.

Measuring the determinants of income diversification from the Tobit regression, results show that the value of household productive assets, household size, climatic shock, and primary level education are among the reasons as to why households diversify their income. On the contrary, the age of household and education at the secondary level or higher shows a negative impact on household income diversification. The study found that gender of household head, marital status, access to credit, access to electricity and household size had no impact on the level of household diversification.

Income diversification was found to have no impact on household food expenditure. This means that more diversified households food spending was not different from households with specialized income. However, income diversification was found to have a positive and significant impact on the households' calorie intake per adult. On average household with more diversified income consumed more calories above the recommended requirement (2360Kcal) than households with less diversified income.

With the current change in the climatic conditions, it is recommended that households adopt diversity in their income sources. In the case of floods or droughts, non-farm income generating activities will provide households with income that can be used to purchase food.

The education sector is another area that requires intervention as most of the illiterate individuals are poor and depend on rain fed agriculture while those with secondary or higher education level are richer and large share of their income comes from wages. Investing in education infrastructure will allow individuals to obtain an education that will provide technical skills and hence open up new opportunities that can increase their income.

Finally, this study focuses on the determinants and effect of income diversification on food security in rural households. However, due to regional disparities in terms of resource endowment, population density, and agro-climate, further studies can be done to study income diversification and food security at the zonal and regional level.

References

Abdulai, A., CroleRees, A., 2001. Determinants of income diversification amongst rural households in Southern Mali. Food Policy 26, 437–452. https://doi.org/10.1016/S0306-9192(01)00013-6

Aborisade, O., Carpio, C.E., 2018. Non-Farm Work and Food Security among Farm Households in Nigeria.

Abubakari, Fariya, Abubakari, Farida, 2015. Determinants of Household Food Security and Climate Change Impacts on Agriculture in Ghana. Acad. Res. J. Agric. Sci. Res. https://doi.org/10.14662/ARJASR2015.015

Agyeman, B.A.S., Asuming-Brempong, S., Onumah, E.E., 2014. Determinants of Income Diversification of Farm Households in the Western Region of Ghana 18.

Aidoo, R., Mensah, J.O., Tuffour, T., 2013. DETERMINANTS OF HOUSEHOLD FOOD SECURITY IN THE SEKYERE-AFRAM PLAINS DISTRICT OF GHANA. Eur. Sci. J. ESJ 9. https://doi.org/10.19044/esj.2013.v9n21p%p

Arene, P.C.J., 2011. Determinants of Food Security among Households in Nsukka Metropolis of Enugu State , Nigeria.

Babatunde, R.O., Qaim, M., 2010. Impact of off-farm income on food security and nutrition in Nigeria. Food Policy 35, 303–311. https://doi.org/10.1016/j.foodpol.2010.01.006

Babatunde, R.O., Qaim, M., 2009. Patterns of income diversification in rural Nigeria: determinants and impacts. Quarterly Journal of International Agriculture. 48. 305-320.

Barrett, C.B., Reardon, T., Webb, P., 2001. Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. Food Policy 26, 315–331. https://doi.org/10.1016/S0306-9192(01)00014-8

Cameron, A.C., Trivedi, P.K., n.d. Microeconometrics : Methods and Applications 1058.

Cordeiro, L.S., Wilde, P.E., Semu, H., Levinson, F.J., 2012. Household Food Security Is Inversely Associated with Undernutrition among Adolescents from Kilosa, Tanzania. J. Nutr. 142, 1741–1747. https://doi.org/10.3945/jn.111.155994

Davis, B., Winters, P., Carletto, G., Covarrubias, K., Quiñones, E.J., Zezza, A., Stamoulis, K., Azzarri, C., DiGiuseppe, S., 2010. A Cross-Country Comparison of Rural Income Generating Activities. World Dev. 38, 48–63. https://doi.org/10.1016/j.worlddev.2009.01.003

de Haen, H., Klasen, S., Qaim, M., 2011. What do we really know? Metrics for food insecurity and undernutrition. Food Policy, Between the Global and the Local, the Material and the Normative: Power struggles in India's Agrifood System 36, 760–769. https://doi.org/10.1016/j.foodpol.2011.08.003

Djurfeldt, A., 2014. Multi-Local Livelihoods and Food Security in Rural Africa. J. Int. Dev. 27. https://doi.org/10.1002/jid.2991

Ecker, O., Mabiso, A., Kennedy, A., Diao, X., 2011. Making Agriculture Pro-Nutrition: Opportunities in Tanzania [WWW Document]. Afr. Portal. URL https://www.africaportal.org/publications/making-agriculture-pro-nutrition-opportunities-in-tanzania/ (accessed 4.16.19).

FAO (Ed.), 2018. Building climate resilience for food security and nutrition, The state of food security and nutrition in the world. FAO, Rome.

Gautam, Y., Andersen, P., 2016. Rural livelihood diversification and household well-being: Insights from Humla, Nepal. J. Rural Stud. 44, 239–249. https://doi.org/10.1016/j.jrurstud.2016.02.001

Haug, R., Hella, J., 2013. The art of balancing food security: securing availability and affordability of food in Tanzania. Food Secur. 5, 415–426. https://doi.org/10.1007/s12571-013-0266-8

Hoang, T.X., Pham, C.S., Ulubaşoğlu, M.A., 2014. Non-farm activity, household expenditure, and poverty reduction in rural Vietnam: 2002–2008. World Dev. 64, 554–568.

Hoddinott, J., n.d. Choosing Outcome Indicators of Household Food Security 29.

J, K., P, M., N, D., N, B., A, M., Z, M., T, J., K, K., D, M., N, A., M, N., Msuya, J., 2016. Food intake and dietary diversity of farming households in Morogoro region,Tanzania. Afr. J. Food Agric. Nutr. Dev. 16, 11295-11309–11309.

Joint Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition, Weltgesundheitsorganisation, FAO, United Nations University (Eds.), 2007. Protein and amino acid requirements in human nutrition: report of a joint WHO/FAO/UNU Expert Consultation ; [Geneva, 9 - 16 April 2002], WHO technical report series. WHO, Geneva.

Loison, S.A., 2015. Rural Livelihood Diversification in Sub-Saharan Africa: A Literature Review. J. Dev. Stud. 51, 1125–1138. https://doi.org/10.1080/00220388.2015.1046445

Loison, S.H.A., Bignebat, C., 2017. Patterns and Determinants of Household Income Diversification in Rural Senegal and Kenya. J. Poverty Alleviation Int. Dev. 8, 93–126.

Lukmanji, Z., Hertzmark, E., n.d. Tanzania Food Composition Tables 272.

Maddala, G.S., 1986. Limited-Dependent and Qualitative Variables in Econometrics (Cambridge Books). Cambridge University Press.

Maddala, G.S., 1983. Limited-Dependent and Qualitative Variables in Econometrics by G. S. Maddala [WWW Document]. Camb. Core. https://doi.org/10.1017/CBO9780511810176

MAFAP (2013). Review of food and agricultural policies in the United Republic of Tanzania. MAFAP Country Report Series, FAO, Rome, Italy.

McGuire, S., 2015. FAO, IFAD, and WFP. The State of Food Insecurity in the World 2015: Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress. Rome: FAO, 2015. Adv. Nutr. 6, 623–624. https://doi.org/10.3945/an.115.009936

National Bureau of Statistics (NBS) [Tanzania]. 2011. Tanzania National Panel Survey Report (NPS) - Wave 2, 2010 - 2011. Dar es Salaam, Tanzania: NBS.

Omotesho, O.A., Adewumi, M.O., Muhammad-Lawal, A., Ayinde, O.E., 2016. Determinants of Food Security Among The Rural Farming Households in Kwara State, Nigeria. Afr. J. Gen. Agric. 2.

Owusu, V., Abdulai, A., Abdul-Rahman, S., 2011. Non-farm work and food security among farm households in Northern Ghana. Food Policy 36, 108–118. https://doi.org/10.1016/j.foodpol.2010.09.002

Petrin, A., Train, K., 2010. A Control Function Approach to Endogeneity in Consumer Choice Models. J. Mark. Res. 47, 3–13. https://doi.org/10.1509/jmkr.47.1.3

Pinstrup-Andersen, P., 2009. Food security: definition and measurement. Food Secur. 1, 5–7. https://doi.org/10.1007/s12571-008-0002-y

Schönfeldt, H.C., Hall, N.G., 2012. Dietary protein quality and malnutrition in Africa. Br. J. Nutr. 108, S69–S76. https://doi.org/10.1017/S0007114512002553

Tuholske, C., 2018. Measures and Determinants of Urban Food Security: Evidence from Accra, Ghana.

United Republic of Tanzania (URT)/Ministry of Agriculture, Food Security and Cooperatives (MAFSC), 2014. Agriculture Climate Resilience Plan 2014-2019. Dar es Salaam: United Republic of Tanzania

van Wesenbeeck, C.F., Keyzer, M.A., Nubé, M., 2009. Estimation of undernutrition and mean calorie intake in Africa: methodology, findings and implications. Int. J. Health Geogr. 8, 37. https://doi.org/10.1186/1476-072X-8-37

Webb, P., Coates, J., Frongillo, E.A., Rogers, B.L., Swindale, A., Bilinsky, P., n.d. Measuring Household Food Insecurity: Why It's So Important and Yet So Difficult to Do1,2 5.

Winters, P., Essam, T., Zezza, A., Davis, B., Carletto, C., 2010. Patterns of Rural Development: A Cross-Country Comparison using Microeconomic Data. J. Agric. Econ. 61, 628–651. https://doi.org/10.1111/j.1477-9552.2010.00265.x

Zhao, J., Barry, P., 2013. Implications of different income diversification indexes: the case of rural China. Econ. Bus. Lett. 2, 13. https://doi.org/10.17811/ebl.2.1.2013.13-20

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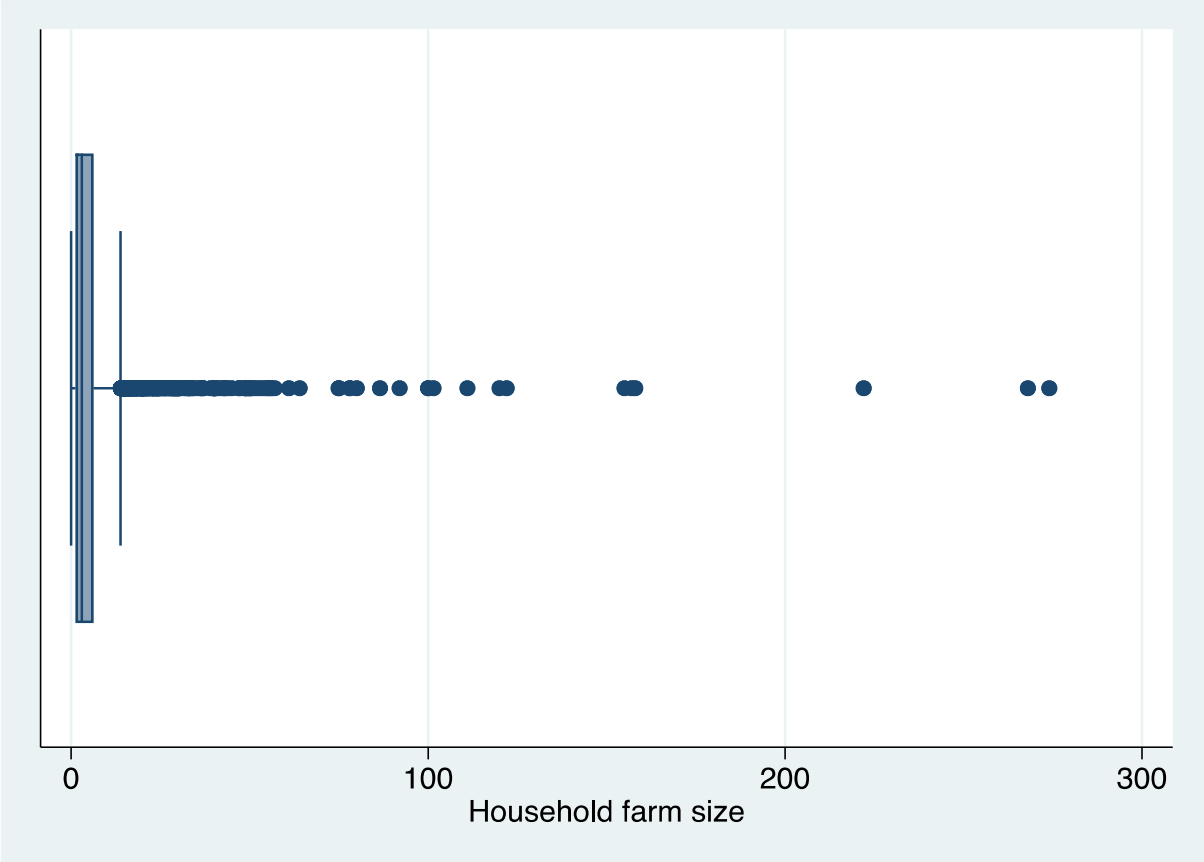
Appendices

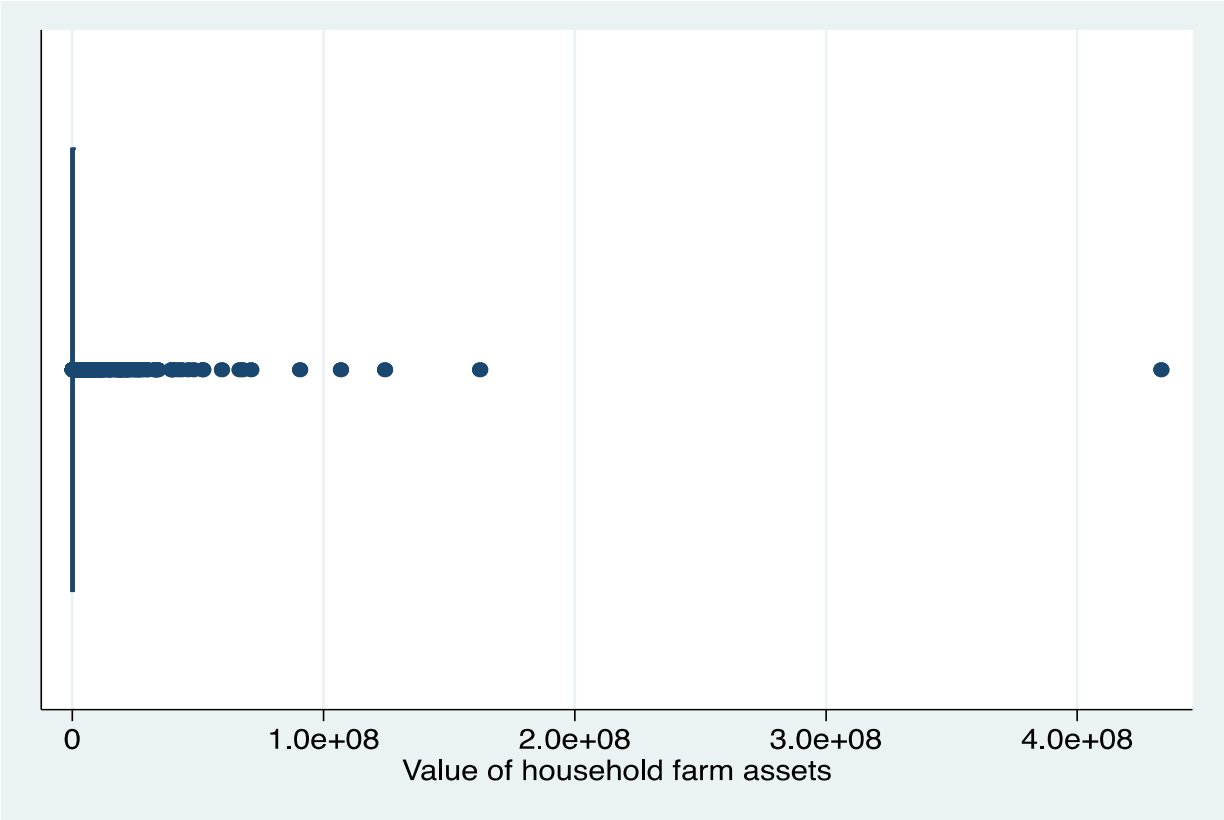
Appendix 1: Household Income sources composition by gender of the household head

Gender	Other Income	Wages	Self-employment	Remittance	Crop sales	Livestock sales
Female	0.84798	14.87445	21.29115	1.05006	48.88718	0.13049
Male	1.32509	14.72138	18.41794	1.04585	50.46385	0.14026
Total	1.22115	14.75472	19.04386	1.04677	50.12038	0.13813

Appendix 2: Household farm size distribution



Appendix 3: Distribution of value of household productive assets



Appendix 2: Correlation matrix

	Gender	Marital Status	Household size	Electricity access	Credit access	Climatic shock	Age	Education	Log Farm size	Log Farm asset
Gender	1									
Marital Status	-0.4669	1								
Household size	0.1882	-0.1688	1							
Electricity access	0.0325	-0.0646	-0.0001	1						
Credit access	0.0123	0.0705	0.0228	-0.0265	1					
Climatic shock	0.0042	0.0024	0.0987	-0.064	-0.0191	1				
Age	-0.1999	0.1075	0.0024	0.07	-0.0605	0.0546	1			
Education	0.2502	-0.153	0.0458	0.194	0.0079	-0.0404	-0.3263	1		
Log Farm size	0.1905	-0.125	0.4623	-0.0723	-0.0259	0.0647	0.0634	0.0115	1	
Log Farm asset	0.1805	-0.1043	0.3152	-0.125	0.0148	0.0807	0.0866	-0.0182	0.4926	1