Social-economic Determinants of Food Security among Smallholder Mixed Farmers in Burera District, Rwanda

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Abstract:
The agricultural sector production is the backbone of the Rwandan economy and has recorded steady increases in the last decade. While Rwanda is classified as food secure at macro level, about half of the households in Rwanda still face seasonal difficulties in accessing adequate food, being at high risk of becoming food insecure in terms of food availability and accessibility. Most of those households at risk are typically rural households who mainly depend on agricultural daily labor for their livelihoods and mostly live on their own farm production. The objective of this study was to investigate the Socio-economic determinants of food security among the mixed smallholder farmers in Burera district of Rwanda. Data were collected from 378 smallholder farmers 'households selected by using a Multi-Stage Random Sampling technique. To collect data, a questionnaire was used through face-to-face interviews. Data were analyzed using descriptive statistics and inferential statistics. Household food security status was assessed and categorized using internationally validated HFIAS tool. Results revealed that only 6.3% of the sampled smallholder farmers' households could be classified as food secure, 15.6% mildly food insecure, 34.7% moderately food insecure and 43.4% severely food insecure. The study also revealed that 77.7% of the respondents were operating on farm size less than one hectare, the half (50.5%) owning between 0.5ha-1ha. About 54.2% had at least one livestock that helps to produce organic manure, with only 15.87% having cows in their households. 42.9% of the respondents earned on farm income range of 200,000-300,000Frw. Regarding availability of on farm labour, 75.1% had less than three active members in their households. About 72% of the respondents did not have access to financial facility and 92% of the respondents did not receive any training in agricultural practices or a home visit of any extension agent within the previous one-year period. Only 25% of the respondents had ever used mineral fertilizers in the previous two agricultural seasons. To analyze the effect of socio-economic determinants of household food security status of the sampled smallholder farmers, Multinomial Logit Model was performed and a prior expectation of signs was made. The results from the model revealed that farm size, on-farm income and gender (women headed households) influenced positively the probability of a household to be in the category of food secure or better off food insecurity level (mild or moderate) when compared to severe food insecurity status. On the hand, family size, not accessing to financial facility, not accessing to agricultural trainings and extension services, as well as education level of the household head had coefficients with negative sign meaning that they negatively influenced the probability of a household to be in better off category of food security status when compared to the severe food insecurity. All these predictors performed according to the prior expected signs except education level of the household head, which might be associated with the fact that more educated members of the household tend to abandon the farming activities while alternative off-farm employment is still limited in the rural areas of Rwanda. Based on the findings that the majority of the smallholder farmers in the study area are experiencing severe food insecurity situation, immediate government and NGOs interventions are deemed imperative to boost agricultural production on small-scale farming. Targeted interventions could include boosting provision of agricultural extension services in the area with more home visits and demonstration of improved farming techniques on small-scale; intensifying highly producing and rapid income generating crops like vegetables coupled with improved value chain to ease access to markets in towns and secondary cities. Given the negative effect of education level, including agricultural training in the curriculum of 12-year basic education could attract more youngsters to farming with improved techniques. However, efforts should be multiplied to create more off-farm employment in rural settings in order to diversify the livelihoods activities as farming land becomes scarcer and more young generation becomes idle after completing the 12-year basic education.

Keywords:
        Food Security: The 1996 World Food Summit defined food security as a situation that exists "when all people at all times have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO,1996).
        Food Availability: this concept refers to the physical existence of food at the household level, be it from own production or from the market. At national level, food availability is a combination of domestic food production, commercial food imports and food aid (InWent, 2010).
        Food Accessibility: Household level Food access is ensured when the household has sufficient resources to obtain appropriate foods for their nutritious diet (InWEnt,2010). Accessibility refers to ability of the household members to acquire food and it depends on the household level resources – capital, labor, and knowledge. Food accessibility at household level is a function of the physical environment, social environment and policy environment which determine the ability of the household to generate sufficient income which, together with own production, can be used to meet food needs (InWent, 2010).
        Smallholder subsistence farming: smallholder subsistence agriculture refers mainly to rural producers in most developing countries who farm on a small piece of land using mainly family labor for production purposely for household consumption (Morton, 2007). According to Rwanda Ministry of Agriculture (MINAGRI,2009), small-holder farmers are the marginal and sub-marginal farm households that own and/or cultivate less than 2.0 hectare of land.

1. Introduction

1.1. Background of the Study

        Across the World, there were approximately 2.5 billion people in 2013 who lived directly from agricultural production systems, either as full or part-time farmers, or as members of farming households that supported farming activities. Out of that number, 80% were classified as smallholder farmers, managing the world estimated 500 million small farms and providing over 80 % of the food consumed in a large part of the developing world, contributing significantly to poverty reduction and food security (IFAD, 2013). Smallholder farmers are characterized by producing food and non-food products on a small scale, with limited external inputs. The Food and Agriculture Organization (FAO) has set a 2-hectare (ha) threshold as a broad measure of a small farm (FAO, 2010). According to IFAD (2011), the vast majority of smallholder farmers live in rural areas. The contributions of smallholder farmers on the world's food security, economy and poverty reduction are very considerable. According to FAO's 2012 factsheet on smallholders and family farmers, smallholder farmers provide up to 80% of food supply in Asian and Sub-Saharan Africa, and 70% of Africa's food supply comes from Smallholder farmers (IFAD, 2013).

        The global trend of smallholder farmers as mentioned above is noticeable as well in Rwanda where the economy still depends mainly on agricultural sector, contributing 33% of GDP (NISR, 2014) and employing about 80% of the workforce, and 90% of them being smallholder subsistence farmers (NISR, 2013). Agricultural sector in Rwanda is dominated by subsistence farming and practiced on the average farm size less than one hectare per household (IFDC, 2007). The sector continues to be characterized by very low levels of inputs use. Raising productivity levels in smallholder farms represents a vital role to economic growth and poverty reduction in Rwanda. The main crops include standing crops such as bananas and cassava; root crops such as Irish potatoes and sweet potatoes; cereals such as maize and sorghum; pulses especially beans. The Government of Rwanda has introduced several projects and programs to improve agriculture and boost food production in the country such as CIP, PSTA I, II and III, land use consolidation policy, One cow per family amongst others. As a result of these interventions, there has been an increase in the use of inputs including agrochemicals, though the average use is still far below the Government targets. The fertilizer application rate in CIP areas has reached an annual average of 29 kg/ha/year in 2011-2012 compared to a national average of 4.2 kg/ha/year from 1998-2005 and in 2013 MINAGRI had set a target average rate of fertilizer to be 45 Kg/ha in 2017 (MINAGRI, 2013). Access to improved seeds, increased areas under irrigation, radical terraces protected against erosion, distribution of livestock through programs such as Girinka, etc. all these are the measures that made the increase of Rwanda's agricultural productivity and production for a number of crops, thus increasing the farmers' income and reducing rural poverty considerably. In 2009, compared to other countries, it was estimated that over the previous decade, only 12 percent of farming population had used improved seed varieties and 5.2 percent of household had used approximately 4 Kg of fertilizer per hectare (GoR, 2009) which was still below the estimated average use of fertilizer in the Sub Saharan Africa (SSA) which was standing at 9 to 11 Kg per hectare (GoR, 2009). Without optimal agricultural inputs such as land, labour, capital, there is no crop production as they are essential to increase agricultural productivity, food output and food security.

        Despite the considerable contribution in the global, regional and national food production, smallholder farmers comprise the majority of the world's undernourished population, and most of those living in absolute poverty (IFAD, 2011a). Smallholder farmers are often relegated to infertile soils and to decreasing plot sizes (De Schutter, 2011). In many parts of the world, smallholder farmers are struggling to maintain food self-sufficiency, mainly due to the decline of land per capita which

leads to fragmentation, particularly in densely populated areas, threatening the ability of the remaining land to provide adequate livelihoods (Jayne and Muyanga, 2012).

The 2015 FAO's State of Food Insecurity in the world indicated that there were still over 795 million people, or one in nine worldwide and one in four within Sub-Saharan Africa who did not have enough to eat in 2015, while 70% of them live in rural areas and depend directly or indirectly on agriculture for their living (FAO, 2015). In Rwanda, despite all the efforts that the Government puts in Agriculture as highlighted above, the level of food insecurity remains exorbitantly high, with minimal reduction on annual basis, from 51% of households having difficulties in accessing adequate food in 2012 to 49% in 2015, especially in the rural households depending mainly on agricultural daily labor and their own agricultural production (WFP, 2012&2015). Many literatures have shown some of the socio- economic characteristics of small holder farmers that might lead to food insecurity such lack of resources, for instance, low income levels, small farm size which limit productivity and thus, decrease farm level revenues. In addition, the culture and level of education of the small holder farmers have been noted to significantly determine the level of farm productivity and subsequent household food security levels (Oni, 2013). Thus, this study will investigate the social –economic determining factors of household food security among small holder's farmers in Burera district, Rwanda.

1.2. Statement of the Problem

Rwanda's economy is largely agrarian and more than 80% of Rwanda's population depends on farming and 95% of these being smallholder farmers (FAO, 2015). However, according to the World Food Programme (2015), most food insecure households are those depending mainly on agricultural production, implying that this segment of the Rwandan population are vulnerable to food insecurity.

While a number of studies have been conducted in relationship to food insecurity in Africa and specifically in Rwanda (FAO, 2012; De Schutter, 2011; Jayne & Muyanga, 2012) none focused on the influence of social economic factors towards food insecurity amongst the small holder farmers. Some of these studies have cited low income generation, small farm size, lack of inputs, lack of resources, limited access to credit, low level of technical skills and inadequate training about farming practices which limit productivity and further increase household food insecurity. There is need to confirm whether these issues lead to low productivity, and subsequent food insecurity amongst the small holder farmers. This information gap provides an opportunity for this kind of study.

1.3. Objectives of the Study

The main objective of this study was to explore the socio-economic determinants of food security among the smallholder farmers in Rwanda.
The specific objectives of the study were:
1. To describe the socio-economic characteristics of the smallholder farmers' households of Burera district.
2. To assess the status of food security at household level among the smallholder farmers of Burera District.
3. To find the effect of resource factors (Farm size, livestock ownership, farm income, on-farm house labor) on food security among the smallholder farmers of Burera District.
4. To determine the influence of demographic characteristics (family size, gender of household head, age of the household head, education) on food security among the smallholder farmers of Burera District.

1.4. Justification and Significance of the Study

While food insecurity and extreme poverty remain persistent in sub-Saharan Africa and particularly in Rwanda, and food and agricultural assistance programs have been implemented broadly since many years, there is little evidence of their impact in uplifting the smallholder farmers and extremely vulnerable households. The 2012 Rwanda Cost of Hunger study showed that an estimated 503.6 billion Rwandan Francs (FRW) were lost in the year 2012 because of child under-nutrition, equivalent to 11.5% of GDP (NEPAD, 2012). The same study found also that 49.2 % of adults in Rwanda suffered from stunting as children and this represented more than 3 million people of working age who were not able to achieve their potential because of undernourishment. The Government of Rwanda in its National Food security and Nutrition Strategic Plan 2013-2018 recognized that the major cause of the high level chronic malnutrition in children in Rwanda was due to inadequate quantity and quality of food consumed at the household level (Rwanda, 2013). Given that 72 % of the Rwandan rural households rely on agricultural production to sustain their livelihoods (WFP, 2015) and the majority of those households (95%) own very small plots of land, less than 2ha, the predominant farming system in the country is smallholder subsistence farming.

It is therefore important that agricultural economics research focuses as well on issues of food insecurity at micro level which are directly linked with insufficient food production under smallholder subsistence farming, and further affects the national economic development. This research will contribute in bridging the knowledge gap on key determining factors of food security among the smallholder farmers in Rwanda. Such determining factors should be considered when designing agricultural and food security policies as well as livelihood programs in the context of empowering and creating resilience among the smallholder farmers, with a particular emphasis to those households already facing chronic food insecurity. The

results of this study provided useful information both for policy makers and researchers in their efforts to improve rural household food security, especially through the combined multi-sectorial efforts of tackling extreme poverty in rural Rwanda.

1.5. Scope of the Study

1.5.1. Context Scope of the Study

This study assessed the socio- economic determinants of food security among smallholder farmers in the context of a developing economy depending basically on subsistence farming such as Rwanda. Given that the concept of food security is very wide with four dimensions of analysis (food availability, food accessibility, food use and utilization and food stability), this study took only into consideration the first two dimensions (food availability and accessibility) which are directly associated with agricultural production and demand at household level.

1.5.2. Geographical Scope of the Study

Research for this study was carried out in one of the rural districts of Rwanda, Burera district in Northern Province. Burera district represents the Northern livelihood zone where the soil type and fertility are considered to be favorable for agricultural farming, but also the climatic conditions are favorable with rain all year long compared to other provinces of the country. This site was selected based on the previous reports that profiled the region to be vulnerable to food insecurity and chronic malnutrition (WFP, 2012). Burera district was also profiled in EICV3 of 2010/2011 to be the second in country to have the largest household size, with average family size of 5 members per household. This makes that the district is characterized with high levels of family land partitioning, leading to typical small-scale farming, with mean size of farm land of 0.39 ha per household, which is below the national average farm land size of 0.59ha per household (NISR, 2011). Within Burera district, data were collected in Butaro sector which also represent the highest populated sector in the district (NISR, 2011).

1.5.3. Scope of the Study in Time

The field data collection of this study was done in the last week of November and first week of December 2016, the time amidst the agricultural season A-2017, when households haven't yet harvested but expecting to harvest. It is also when most of the small farmers' households are assumed to consume the stock from the previous harvests, thus allowing to assess if food stock takes them from one harvest to another. This helped to reduce the bias in answering the questions related to food insecurity experiences.

1.6. Limitations of the Study

Due to limited means, the sample of the study could not be drawn across the whole Burera district. The sample frame was limited to Butaro sector. Also, the collected data on resource factors of agricultural production were self-reported from the interviews with the household heads, thus at some level the estimates might not be fully accurate. Due to time constraints and inaccessibility of accurate measurement tools, the researcher could not counter-verify the estimates given by respondents such as accurate farm land size, estimated income from farming activities, etc.

There are also several tools to measure household food security status, this study used the 30 days experience-based household food security measurement tool, the Household Food Insecurity Access Scale Score (HFIAS), which has been validated and used across many countries including the Easter African Region, in Tanzania and Burundi which have similar conditions as Rwanda (Knueppel et al.,2010). Therefore another research using a different tool could come up with different food security status classification and different proportions of food secure and food insecure.

2. Literature Review

An attempt was made to review the studies conducted by various researchers on the socio-economic determinant of food security. This chapter is subdivided into three sections as follows: the first section deals with the theoretical framework followed by conceptual framework, the second section deals with empirical review of the socio-economic determinants of household food security and measurement of food security

2.1. Theoretical Framework

A clear understanding of the theory of food security is very important to better understand the applicability of the theory in assessing household food security and its determinants. The major theories considered in the present study include Food Availability Decline (FAD), Food Endowment and Entitlement Theory (FED) and Robert Malthus's population theory. FAD explains the impacts of land degradation, lack of productive resources and population pressure on the availability of household food security. The disruption of agricultural production leads to the decline in food availability of the household (Degafe, 2002). To examine the main hindrances for the agricultural production, which in turn lead to decline in food availability, FAD model can be used. To analyze the household food access, FED (Food Entitlement Theory) focuses on an individual/ household's purchasing power which gives him or her access to food. Malthus theory on the other hand defines the relationship between food production and food supply and population growth.

2.1.1. Food Availability Decline (FAD) Theory

The food availability decline Approach had been a dominant theoretical explanatory framework for food insecurity. As stated by Francesco Sarracino (2010), the FAD approach points out the insufficient production and availability of food as the main causes of food insecurity which leads to extreme cases of famines and starvation. Under FAD theory, food availability is defined as when all people have sufficient quantities of food available on a consistent basis. Food available is determined by the food production (FAO, 2008). The FAD theory focuses on the question of why people are food insecure. The answer to this question is that it is because of the insufficient food supply. As a consequence of insufficient supply, the prices go up and people who are not able to bear such an increase consume less calories. FAD theory states that anything that disrupts food production can cause food insecurity since it might cause a food supply decline below the subsistence needs of the population of a given region. This theory is necessary to prevent food insecurity. To conclude, this approach conceived famine as shortages of food supplies per capita, favored by natural factors such drought, floods and the calamities that affect negatively the crops yield, or demographic factors such as gender, age, educational level, etc. (Diana, 2007). The FAD approach has been criticized for its focus on collective supply rather than the capacity of a household to have access to food. Yaro (2004) confirmed that this approach does not explain how individuals/farmers have access to food. The gaps left by the FAD approach led to the emergence of the entitlement theory.

2.1.2. Endowment and Entitlement Theory

The FAD approach did not offer adequate explanations to the paradox of why in the abundance of food a significant number of people are food insecure. As cited by Sarracino (2010), Amartya Sen (1981) explained that to study food security, one needs to go beyond looking at food availability, to consider the general economy and also the political and social environments which make it possible for people to have access to food. Therefore, the entitlement approach emerged to consider a broader sense of food security other than production and agricultural expansion which are the concerns of the FAD approach.

According to Amartya Sen who is the pioneer of the entitlement approach, a famine can occur without a decline in the food production. He also observed that FAD does not center its attention on who suffers during a famine (Sarracino, 2010). The basic question of entitlement approach is why we still have famines while food production is still enough? To answer this question, based on his personal experience in his life in India, Sen argues that famines are caused by lack of access to food. To solve the issue of famines, Sen promoted the idea of entitlement approach. He divided entitlement approach into two categories: endowment set and the entitlement set. To produce food, a farmer needs a set of resources known as endowments. These resources are assets such as land, labor, fertilizers, capital, education, farmers' skills, etc. The entitlement set refers to the products obtained from using the resources into the production process. The entitlement set usually depends on the combination of resources or endowments set that a farmer chooses. The endowment set refers to the inputs whereas the entitlement set represents the outputs. The connection between the inputs and outputs is known as the entitlement mapping. For example, the relationship between the amount of resources employed on a farm and the output realized from production. Then to transform these endowments into production requires knowledge, technology, skills and experience (Sarracino, 2010). Briefly, to satisfy one's entitlement to food, the endowments should be put into production or one's income in an employment can give her access to food. This has been described as interdependence because people who are not directly into food production but in others sectors such as industry and services have access to food because they are able to use their incomes to command for food (Sen, 1999; Sarracino, 2010). The entitlement approach focuses on an individual's' purchasing power which gives him or her access to food. This is interpreted by Sen when he gives the following statement: "Food is not distributed in the economy through charity or some system of automatic sharing. The ability to acquire food has to be assessed. What we have to concentrate on is not the total food production in the economy but the entitlement that each person enjoys: the commodities over which she can establish her or his ownership and command." (Sarracino, 2010).

2.1.3. The Malthusian Theory or Population-Driven Theory

Thomas Robert Malthus (1766-1834) was a British economist, clergyman and demographer, educated at Jesus College, university of Cambridge. Malthus was a professor of political economy and Modern History at the college the East India Company at Haileybury. Malthus' contribution to economics was his theory of population, published in "An Essay on the principle of Population" (1798). According to Malthus, population tends to increase faster than the supply of food available for its needs. Whenever a relative gain occurs in food production over population growth, a higher rate of population increase is stimulated. On the other hand, if the population size increases higher than food production, the growth could only be checked by natural disasters such famine, disease, war etc.
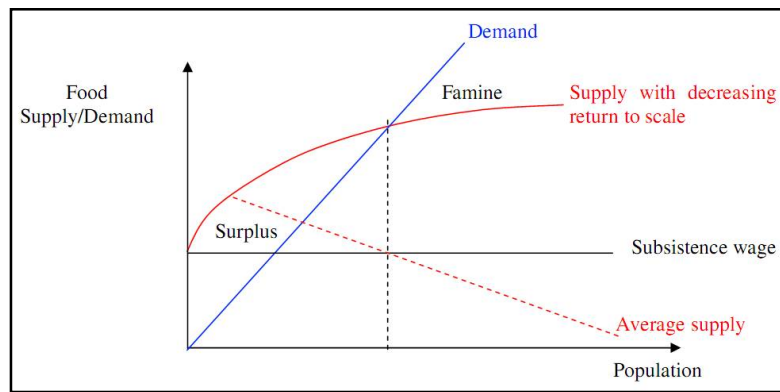
Figure 1: The Malthusian Population Theory
Source: Sarracino, 2010

Malthus argues that high fertility and population growth lead to ecological problems in terms of over cultivation, excess fertilizer use, deforestation, desert, soil degradation, etc. These practices lead to food insecurity (Sarracino, 2010). His idea of food supply became widely popular when he talked about the food insecurity and hunger. He stated that the food insecurity and hunger are caused by the lack of food supply because the growth of population creates more food demand. Malthus proposed instrumental policies to control the population growth including female education and promoting easy access to contraception.

2.1.4. Application of FAD and FED Theories

A study entitled "Household Food Security Status and Its Determinants in Ethiopia conducted by Meskerem and Degefa (2015) applied Food Availability (FAD) and Food Entitlement Decline (FED) theories to understand the determinants of food security in Oromia region of Ethiopia. Gender, Age, Educational status and household size were the main demographic factors used to determine their impact on food security. Regarding gender of a household head, there was a difference in food security between female-headed and male-headed household. Their results showed that food security status of household headed by male was found to be higher than that headed by a female.

Concerning educational status, the results revealed that education level influences food security through production management, adopting improved technologies that lead to increase in crop production. They found that food security of a household head who is literate was relatively higher as compared to illiterate heads. About Age factor of the household head, it was found to affect positively the household food security up to 70 years old while a household age with more than 70 affects negatively food security due to other factors such as shortage of labor force. They also found that as the number of household size increases, food security increases too and they conclude that active household size affects positively a given household.

Meskerem and Degefa (2015) used economic factors such as on-farm, off-farm income, farm size, number of farm oxen available, and types of farm inputs to examine their impacts on food security. Regarding farm size the impact of it was positive: the higher large farm size, the higher food security status compared to those who owned small farm size. They found also a positive relationship between the number of oxen owned by a household head and food security status. From these theories, the existing relationship between different factors and food security will be reviewed in the conceptual framework below (Fig.2.2)

2.2. Conceptual Framework of the Smallholder Farmers Food Security at Household Level

In economics, factors of production, resources, raw materials, inputs are used in the production process to produce the outputs. The utilized amounts of the various inputs determine the quantity of output. Thus, the relationship is called the production function. To this end, this section describes the relationship of the factors influencing food security. The conceptual framework guiding this study is shown in Fig.2. Drawing on existing literature and the conceptual framework of the socio-economic factors of household food security, we postulate that household food security is directly influenced by Resource factors and socio-demographic characteristics of the household, while institutional factors play as intervening or moderating factors. Regarding resource factors, farm size, labor availability and on-farm income will be analyzed. The demographic factors such as household Age, gender, education level and size of the household will be taken into account and lastly, institutional factors including access to financial facilities (savings and credits) and access to agricultural trainings and extension services will be studied. These factors have been documented in the literature review to have direct effect on household food security and the outcome of the study will provide an understanding of whether the smallholder farmers' households in Burera district are food secure or not. The relationship between household food security and determining factors are briefly explained as follows.
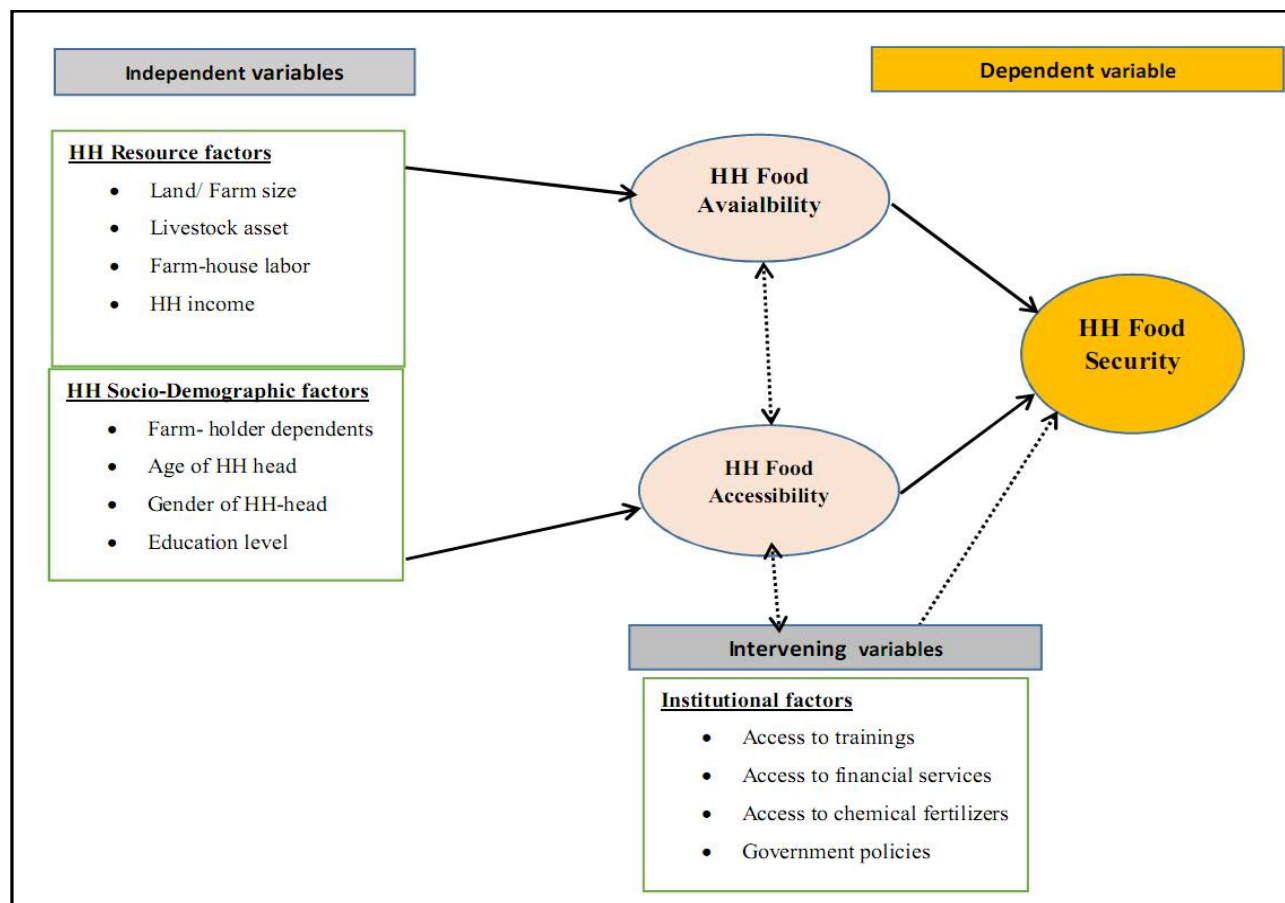
Figure 2: The conceptual framework of smallholder farmers' food security at household level
Source: Own construct

2.3. Empirical Review of the Determinants of Household Food Security

2.3.1. Demographic Factors
Demographic characteristics that determine household food security including gender, age, educational level and household size are explained below:

2.3.1.1. Gender and Household Food Security
        Chomba (2011) conducted a study on "Gender and household food security: A case study of Kalulushi district, Zambia". He found that male headed households were more likely to grow different crops compared to women headed unit and this makes a household headed by male to be more food secure compared to a household headed by a female. As stated by Dagmar and Ivy in their paper entitled "Gender Roles in Ensuring Food Security", it was recognized that women produce between 60 and 80 percent of the food in sub-Saharan African countries and were responsible for a half of the World's food production (FAO, 1998). According to FAO's 2012 Factsheet on "Smallholders and Family Farmers", women comprise an average of 43% of the agricultural labor force of developing countries up to almost 50% in Eastern and Southern Asia and Sub-Saharan Africa. The same fact sheet states that "should women farmers have the same access to productive resources as men, they could increase yields on their farms by 20-30 %" (FAO, 2012).
        There are however many controversial statements in literature arguing that women managed households are more prone to food deficit. Allen and Thompson (1988) had concluded that the female headed households are significantly more likely to be in poverty than those headed by the male. But Kennedy and Peters (1992) found that although many female-headed households are poorer than their male counterpart, there is an impression that food security and nutritional status of individual members in the household is significantly better in the household headed by women. The rational of this significant difference in welfare of the household members within female-headed household compared to male –headed has been attributed to the fact that the higher proportion of women's income is spent on food compared to the income of their male counterpart. FAO (1989) had also reported that compared to men's spending pattern, women spending tend to be more on basic food supply.

2.3.1.2. Age and Household Food Security

Bashir et al (2013) found a negative relationship between the age of the household head and food security in Pakistan, while Jemal and Kyung (2012) found that age of the household head was strongly and positively affecting food security in rural Ethiopia. Godwin (2016) found that the probability of households being food secure or food insecure in rural areas of Benue was determined by age. Result from his study revealed that the coefficient of age was found to be negative and significant at 5 % which means that food security declines with increase in age of the household head. The negative and significant effects of age of the household heads decrease the probability of households to be food secure. Agboola (2004) in his study on an economic analysis of household food insecurity and coping strategies in Osun state of Nigeria reported that age was negatively and significantly affecting food security, in other words, if the age of a household head increases the status of food security decreases.

2.3.1.3. Education and Household Food Security

Aminu (2013) conducted a study on the relationship between educational attainment and food security in Nigeria. He found a negative robust correlation between the level of education and food security status among households in Nigeria. The direct effect of education or the net effect of education on food security and can be referred to as the impact of education of the household head on food security other things being equal (Baron and Kenny, 1986). Moses and Maurica (2016) conducted a study on the effect of education on household food security in Kenya, the results showed a significant effect of education on food security. The probability of being food insecure decreased by 0.019 for a unit increase in the average year of schooling for a given household. The results of the study conducted by Bashir, at al. (2013) showed that education levels affect positively a household food security. Francesco and Pasquale (2007) in their working paper on education for rural people called education as "a neglected key to food security". They found that education was negatively associated with food insecurity, that is the greater the educational level, the lower the average of food insecurity. It means that the association between food insecurity and primary education is very high and it decreases progressively with basic, secondary and tertiary education.

2.3.1.4. Household Size and Household Food Security

Adebayo studied the effects of family size on household food security in Osuna state, Nigeria. He found that about 60.9 % had family size of 5 and 8 members only 24.5% were food secure. A study conducted by Bashir (2013) revealed that household size has a negative impact on food security. Oluwaseun (2015) found a negative relationship between household size and food security in the study conducted in Kaduna state, Nigeria. Household size was statistically significant and influences the probability of being food secure in the study area. From the findings of the study, they suggested that there is a need to create an enabling environment for smallholder farmers to improve their levels of productivity through appropriate government policies and strategies (Oni S.A et al, 2013). By the help of the logistic results Gabriella (2016) found that the size of household was significantly and negatively affected food security in the Eastern region. Omotesho et al. (2006) conducted a study on the determinants of food security among the rural farming households in Kwara state of Nigeria. They found that on third of the sampled rural farming households were food insecure and household size affected positively food security in the study area.

2.3.2. Resources Factors/ Economic Factors

Economic factors have a significant role in helping or limiting a household to be food secure through production or purchase from market. The extent to which a household obtains cash income matters a lot in improving agricultural activities and improve food production. Economic factors such as, total income, number of employed people in the household and Farm-size will be analyzed.

2.3.2.1. Total Farm Income and Household Food Security

Abu-Bakr (2010) found the positive relationship between income and food security. He concluded that the higher the level of income the more food security a household is in Gombe State, Nigeria. Gabriella (2016) worked on the comparative analysis of food security status of farming households in Eastern and Northern Regions of Ghana. Results from the logistic model revealed that monthly households' income was positively and significantly affected households' food security in eastern region. Maksuda and Taj (2012) conducted a study on the socio-economic factors influencing food security status of maize growing farmers in selected areas of Bogra district. They found that monthly on-farm income affected positively household food security as an increased income of household head increase food security status. Ahmed (2015) revealed that, off-farm income was significant and positively affect food security status of the households which means that farmers engaged in off-farm activities have better chance to be food secure. The summation of the on-farm and off-farm income will form an aggregate income called total income. Mauricio Reis (2006) found that household per capita income decreases with the intensity of food insecurity. He compared also per capita income of household food security with per capita income of household food insecurity and he found that the average household per capita income of food security is more than twice that of households with food insecurity and more than four times higher when compared to households with severely food insecurity. Oni S.A et al (2013) found that total income in farming was statistically significant and influence the probability of being food secure in the study area. From the findings of the study, they suggested that there is a need to create an enabling

environment for smallholder farmers to improve their levels of productivity through appropriate government policies and strategies.

2.3.2.2. Farm-Size and Household Food Security

The results of a study conducted by Ahmed (2015) showed that farm size owned by household heads was positively affect food security status of households i.e. the larger the farm size, the better food secure status of the household. Robert, et al. (2013) revealed that farm size was found to influence positively food security as larger a farm size was find to be food secure compared household with smaller farm size, ceteris paribus. Keshav (2006) in his study on the household Food Security in Rural areas of Nepal revealed that the average farm size of food secure household is almost double that of food insecure household. A study on the assessment of the contribution of smallholder irrigation to household food security in comparison to dry land farming in Vhembe district of Limpopo Province, South Africa conducted by Oni et al. (2011) found that farm size was negatively and significantly influenced food security. It means that the likelihood of a household being food secure decreases with an increase in farm size.

2.3.3. Institutional Factors

Institutional factors that determine household food security including access to credit, and training participation are explained below:

2.3.3.1. Access to Credit

Abdul (2015) found that the higher the amount of credit obtained from the formal source, the more food secured is the farmer household. Aliou and International Food Policy Research Institute (1998) conducted a study on the impact of access to credit on income and food security in Malawi, the result showed that everything being equal, access to formal credit has significantly affect food security for credit program members as compared to non-credit members. Oluwawaseun (2015) in his study entitled "Analysis of Farm Household and Community Food security in Kaduna State of Nigeria found consumer credit to be significant at 10% level and it influenced negatively the status of food security. He highlighted the reasons for this impact by saying that users of credit do not use the credits for the purpose for which they were asked. Pilirani, et al. (2009) found a positive relationship between access to credit and food security which means that a household with better access to credit are more likely to be food secure.

2.3.3.2. Access to training and Household Food Security

Kipkurgat and Tuigong (2015) in their study on "Impact of agricultural Extension on Food Security among small scale farmers in Wareng District, Kenya", it is recognized that agricultural extension services range from transfer of mono-crop technology to participatory problem solving educational approaches which aim at reducing and enhancing community involvement in the process of development. Agricultural extension services mainly involve the passing of agricultural information to the farmers. It may not always be possible to precisely quantify the contribution of extension services to food security, but agricultural extension is important because in the first place, information about good or new agricultural practices can be synthesized and made available to use by other; can be used to investigate or disseminate knowledge or the creation of organizational administrative set up. However, Stewart R et al. (2016) in their meta-analysis of literature on "effects of training, innovation and new technology on African Smallholder farmers' economic outcomes and food security" were not able to identify any evidence in assessing the effects of training interventions on smallholder farmers' food security.

2.4. Assessment of the Level of Household Food Security

Chinweoke (2015) measured "Household food security status in Taraba state, Nigeria, comparing key indicators". The study focused on assessing the complementary relationship between three key food security indicators such as the Household Food Insecurity Access Scale (HFIAS), the Dietary Diversity Score (DDS) and the Coping Strategies Index (CSI). A questionnaire containing the adapted versions of HFIAS, CSI and DDS was used as an interview guide to collect data on food security, socio-economic characteristics. Simple random sampling method was adapted to select the households in Taraba State equal to 409. The results of the survey revealed that 8% of the households were food secure, 69% were severely food insecure. Coping strategies index showed that 34% of the households used very erosive coping strategies. The bivariate analysis showed a significant difference (p<0.01) in DDS and CSI across HFIAS categories.

Elodie, et al. (2007) conducted a study on "The Household Food Insecurity Access Scale and Index-Member Dietary Diversity Score Contribute Valid and Complementary Information on Household Food Insecurity in Urban West-Africa Setting". The objective of the study was to assess the performance of the household food insecurity access scale and an index-member's dietary diversity score (IDDS) to approximate the adequacy of urban food security. A survey unit was the household, which was defined as group of persons sharing housing and meals, managing a common budget and led by a head of household. Households were randomly selected through a two-stage cluster sampling method. First, 60 enumerator areas among the 1069 covering the whole city of Ouagadougou were selected proportionally to their size in number of households. in each area, 50 households were randomly selected using the random-walk method from 5 starting points and a random sample of 1056 household were selected.

Maksuda (2012) studied the socio-economic factors influencing food security status of maize growing households in selected areas of Bogra district, Bangladesh. To collect data, a questionnaire was administrated through face to face interviews. Data were collected from 60 farmers who were selected using a stratified random sampling method. The sample farmers were classified according to their land holding size as small, medium and large. Data were analyzed using descriptive statistics and logit model. The results from logit model indicated that age of the household head, household siz, monthly agricultural income and food expenditure influence food security. The results show also that 33.33 percent of the households were found to be food insecure and 66.67 percent of the households were food secure.

Nahid, et al. (2014) Carried out the study to assess the validity and application of the Household Food Insecurity Access Scale (HFIAS) in measuring household food insecurity in the urban area of Varamin city, Iran. They conducted a household survey and 400 households from different parts of the urban areas of Varamin were selected by using a multi-stage random sampling method. HFIAS was used to measure the household food security and a questionnaire of 9-questions that asks whether a specific condition associated with the experience of food insecurity ever occurred during the previous 30 days. To get answer of those 9 questions, households were classified into four groups: food secure, mildly, moderately and severely food insecure. In the second stage of the study, 30 households from each food security group were randomly selected to evaluate the validity and reliability of the HFIAS questionnaire. They found that, Food security was observed in 21% of households, mildly household food insecure was found to be 46.5%, moderately household food insecure was 25.0% and severely household food insecure was 7.5%.

Knueppel, et al. (2008) studied the Valivadation of the Household Food Insecurity Access Scale in Rural Tanzania. The purpose of the study was to test the validity, internal consistency and convergent validity of the Household Food Insecurity Access (HFIAS) in measuring household food insecurity in rural Tanzania and to determine the socio0economic characteristics associated with household food insecurity. Key informant's interviews were conduct contacted with twenty-one purposively selected male and female village leaders. About the household surveys, a sample of 237 households was selected. The results showed that, approximately 20.7% of the households were categorized as food-secure, 8.4% as mildly food insecure, 22.8% as moderately food-secure and 48.1% as severely food-insecure. Cronbach Alpha (α) was used to measure the internal consistency (reliability) of the scale and it was found to be 0.90 which indicates a high level of internal consistency of the scale. Food security was positively associated with maternal education, husband's education, household wealth status, being an agricultural rather than pastoral tribe and it was negatively associated with maternal age and household size. They concluded that, The HFIAS tool shows validity and reliability in measuring household food insecurity among poor households in Tanzania.

Seifu et al. (2015) studied the applicability of Household Food Insecurity Scale to measure food insecurity in Urban and rural households of Ethiopia. A community-based, cross-sectional study design was employed between November and December, 2013. They administered the survey questionnaire twice to the study participants after seven days of the first administration. The repeated survey was used to determine the reproducibility of the household food insecurity assessment tool (HFIAS). A total of 1,516 households (767 in the first round and 749 in the second round) were studied across the two rounds of data collection. Findings of the socio-economic of the respondents show that, the mean age of the respondents was 36,9 years, majority (73.7%) of the respondents was Muslims, about the marital status it was found that 65.1% of the respondents were married, concerning the occupational status the result of the study revealed that 32.5% of the respondents were the housewives and 31.3% were both housewives and farmers. findings of the responses for the items ranged from 2.0% to 76.1% and 0.1% to 80.3% among urban and rural samples revealed that affirmative responses were highest for items showing mild to moderate forms of food insecurity such as worry about food, unable to eat preferred foods, eating a limited variety of food and eating smaller or fewer meals a day.

2.5 Food Security Indicators

2.5.1. Food Availability as Indicator of Household Food Security

Coates et Al (2006) indicated that food availability as indicator of food security refers to the food supply which should be sufficient in quantity and quality and as well as providing a variety of food choices. According to Khan and Gill (2009) food availability is when sufficient quantities of food are available at all times to a household and all individuals of that particular household. Hence, a household that does not have sufficient food available at their disposal is classified as food insecure, turns to be more vulnerable to hunger, and malnutrition. However, food availability alone cannot be relied on to assess household food security. Jacobs (2009) argues that food availability is a weak indicator of the nutrient content and quality of food consumed and does not provide information on food quality and nutrient intake.

2.5.2. Food Accessibility as Indicator of Household Food Security

Access to food is when a household and all members of the household have enough resources to acquire food and meet the nutritional requirements and dietary needs of the household (Khan and Gill, 2009). Therefore, a household to be food secure, food at their access should be adequate both in quantity and quality at all level and at all times. Food accessibility through food production is one of the most important components of food security to achieve food security at household level (Omotesho, et al. 2010). However, it should be noted that food security at the national level does not guarantee that all the

poor will have access to the food required due to the existing regional, economic and social inequalities. There may be prevalence of food insecurity and hunger for some of the rural households due to the fact that they do not produce sufficient food or do not have the purchasing power to afford their food needs (Omotesho et al, 2010).

Food accessibility is determined by the ability of households to obtain food from their own production, stocks and market, as well as the availability of resources which defines the set of productive activities households can pursue in meeting their food and other material needs (FAO, 2003).

Jacobs (2009) further indicates that household food security depends mainly on household income and wealth status which may allow these households to access food. For instance, a low-income household is more likely to experience food shortages than a wealthier household because the latter household will have purchasing power than the former household (Jacobs, 2009).

2.6. HFIAS as a Measurement Tool of Household Food Security

The appropriate measurement of food security is critical for targeting food and economic aid; supporting early famine warning and global monitoring systems and development programs; and informing government policy across many sectors (Jones et al., 2013). However, measuring food security is still a complicated task, due to multiple approaches and diverse tools used throughout history and in multi-cultural contexts. Food security metrics may focus on food availability, access, utilization, stability of food security over time, or combination of these domains. Depending on the purpose, metrics may focus on national level, regional, household or individual level data. From the compendium of Andrew Jones et al (2013), the currently available food security metrics were grouped into:

- Tools that provide national-level estimates of food security,
- Tools aimed at informing the global monitoring and early warning systems;
- Those that assess household food access and acquisition; and
- Tools that measure food consumption and utilization

For the purpose of this study, our focus is on a tool that measures the household level food availability and accessibility. As explained earlier, food access refers to physical and economic access to food.

HFIAS tool has been internationally tested and validated to be a direct, experience-based approach to measuring household food security, while most of other tools used have been classified as indirect proxies or "second generation" indicators (Barret, 2002). HFIAS tool is a set of 9 generic questions (Appendix1) developed and thought to represent the universal domains of the access component of household food security (Coates, 2006). This set of nine questions asked on a recall period of last 30 days generates a score from zero to 27 that is designed to reflect a single statistical dimension of food security, with the aim of providing programs a simple tool for targeting, monitoring and evaluation efforts. Since its development, the HFIAS has been widely used and validated across many countries in the different parts of the world, including Tanzania, one of the East African countries with similar cultural context to Rwanda (Knueppel, 2010).

2.7. Critique of Available Literature

All the surveyed literatures emphasized on the determinants of food security by including different influencing factors in different models of food security. Literatures also indicate that countries that have been able to increase agriculture production and export of agricultural products have generally been those in which food security was improved (FAO, 2006). However, in Rwanda that relationship has not been clarified. Agriculture sector in Rwanda has historically been the backbone of the economy. In addition to its contribution to GDP, it generates about 90% of employment, 70% of export revenues and 90% of national food needed but food insecurity has remained high especially in rural areas (IPAR, 2009). It is therefore important to identify the factors that affect food security at household level among the smallholder farmers who constitute the majority of rural households in Rwanda.

2.7. Literature Gap

Throughout the review of the existing literature, there was no other empirical research found that has ever assessed the effect of resource and socio-demographic factors on food security of smallholders in Rwanda. Thus, to the best of my knowledge, the conceptual framework of this study has never been applied for any other study in Rwanda. By applying it, this study hopes to elicit and clarify many issues that impede to achieve food security in Rwanda in general and in particular among smallholder rural farmers, and therefore recommend possible measures. It is an intention of this study to derive knowledge on how to raise the number of households which are food secure while also increasing crop productivity by equipping farmers with practical skills that will lead to rural poverty reduction and food security. It is also the objective of this study to come up with a new model that shall attempt to explain how agriculture in Rwanda can enable the achievement of food security.

Most of the economic studies on the determinants of food security have focused on food security as a whole by including all the factors such as demographic, economic, institutional and cultural factors. However; studies on the impact of socio-economic determinants on food security are very limited. Also, previous studies using cross-sectional data among smallholder farmers have not focused on mixed crops. The present study has paid its attention to study the mixed wide range of crops as source of food availability at household level.

It is also important to note that earlier studies on the determinants of food security have been mostly conducted in the developing countries. The results from these studies were not homogeneous because of different agricultural systems, geographical characteristics and technological states of the countries. Thus, the results of these studies cannot be directly extrapolated to Rwanda, due to the social, economic, cultural and technological differences. The lack of appropriate literature in the context of Rwanda calls for more studies on agricultural production and food security in Rwanda. Hence this study attempted to bridge the knowledge gap about the socio-economic determinant of food security among smallholder farmers in Rwanda.

3. Research Methodology

3.1. Research Design

The study design was a cross sectional survey, using both quantitative and qualitative data collection approaches. The quantitative data were collected on resource, demographic variables and institutional (moderating) variables, while qualitative approach (combining opinions inquiry and observations) was used to properly record the respondents' household experience with food insecurity and possible reasons.

3.2. Target Population and Sampling Techniques

This research focused on smallholder farmers' households of Burera District, Butaro sector. A Multi-Stage Random Sampling technique was used. In the first stage, Northern Province was purposively selected based on the data from the 2012 WFP's comprehensive Food Security and Vulnerability analysis (WFP, 2012) which had ranked the Northern Province as the most vulnerable province in terms of food insecurity and chronic malnutrition (WFP, 2012). In the second stage, Burera district was considered due to the high rate of households with food insecurity among all the districts of Northern Province (WFP, 2012). Butaro sector of Burera district was selected on third stage due to its highest population density (NISR,2013). A Simple Random Sampling technique was used to select a sample from estimated 6917 households of Butaro sector (NISR,2013). In the EICV3 of 2011, it was estimated that 91.3% of the total households in Burera district were living on farm size less than 0.9ha of land, with a mean of 0.39ha (NISR, 2011). From this profile of the district, this study assumed that all the households of Butaro sector would meet the category of smallholder farmers whose benchmark is set at below 2ha of land.

3.3. Sample Size Calculation

A sample is a small representation of a large population selected from the latter in such a way that they are representative of the universe (Saravanavel, 2008).
The sample size of this study was computed using Yamane's scientific formula as shown below:

$$n = \frac{N}{1 + N(e)2}$$

Where n is the sample size, N is the population size and e is the level of precision or the sampling error.
Population size was 6917 households. Therefore, the sample selected in the population was computed based on the formula as follows:

$$n = \frac{6917}{1 + 6917(0.05)2} = 378 \text{ Household heads.}$$

3.4. Data Collection Tools and Procedures

A closed ended questionnaire was used to collect data for study. Its adoption was based on the ease of use cost effectiveness and rapidity in data collection. The questionnaire was administered directly to the respondents. This tool provided the primary data, while secondary data were sourced through review of journals and reports.

3.4.1. Pilot Testing

The instrument for data collection was first piloted on 19 respondents who constituted a 5% of the calculated sample size of 378. The pilot sub sample was obtained from non-respondents of main sample of this study. The purpose of the pilot testing was to confirm clarity of the questions asked and determine the reliability of the instrument.

3.5. Data Processing and Analysis

The collected data were edited, coded, entered, tabulated and summarized before the analysis. M.S-Excel and Statistical package for Social Sciences (SPSS) software were used to generate the output for analysis.
3.5.1. Analytical Tools and Hypotheses Testing

3.5.1.1. Descriptive Statistics

Descriptive Statistics were used to describe the profile of respondents with regards to social- demographic characteristics of the respondent smallholder farmers' households. Descriptive statistics were also used for food security status categorization of households.

3.5.1.2. Inferential Statistics

Inferential statistics were used to assess the strength of the relationship between independent (causal) variables and dependent (effect) variable. The relationship between household food security status categories and its determinants were studied through multinomial logistic regression model and the impact of each explanatory variable on the dependent variable was analyzed.

Hypothesis testing was also performed assesses if premises were actually true or false for the data set. Maximum Likelihood Ratio test was applied to estimate the parameters of the logistic regression model, Wald statistic test was used to test the significance of the determinants of food security to be able to reject or accept the null hypotheses.

3.5.2. Model Specification

Given that there were more than two categories of the dependent variable being assessed (food security status), the multinomial logit model (MLM) was used to analyze the socio-economic determinants of household food security among mixed small holder farmers in Burera district. The model was preferred because it enables the analysis of more than two categories in the dependent variable, contrary to the binary probit and logit models which are limited to a maximum of two categories (Allen Agresti, 2007). Given the result of this study, it was possible for the households to be divided into four categories: those who were in the category of food secure, those who were in the category of mildly food insecure, those who were in the category of moderately food insecure and those who were in the category of severely food insecure.

Their categories and codes used in the regression are presented in Table 1

Household Food Security Status	Code
Food Secure (FI)	1
Mildly Food Insecure (MFI$_1$)	2
Moderately Food Insecure MFI$_2$)	3
Severely Food Insure (SFI)	4

Table 1: Dependent variable categories

The MLM model was expressed as follows:

$$p(y = j \,/\, x) = \exp(x\,\beta\,j) \,/\, \left[1 + \sum_{h=1}^{j} \exp(x\beta_h) \right] \qquad (1)$$

Where, y denotes a dependent variable taking the values {1, 2,......J} for J>0 and x denotes a set of independent variables. X is a 1*K vector. In this study y represents household food security status while x represents the set of demographic, productive resources and institutional factors. The question was how changes in these factors affect the response probabilities p(y=j/x).

The empirical specification for examining the influence of the explanatory variables (Xi) on the household food security (Y) was given as follows:

$Y_{i=1,.....j} = \beta_0 + \beta_1 AgHH + \beta_2 Gen + \beta_3 Edu + \beta_4 FMS + \beta_5 FS + \beta_6 OnFI + \beta_7 FHL + \beta_8 AFF + \beta_9 TA + \beta_{10} TFert + \beta_{11} LOwn + \varepsilon_i$

X_1= Age of the household head (AgHH)

X_2=Gender of the household head (1 if male, 0 if female)

X_3= level of education (Years of schooling)

X_4= Family Size (FMS)

X_5= Farm size (FS)

X_6= On-Farm Income (onFI)

X_7= Family house labour (FHL)

X_8= Access to financial facility (AFF)

X_9= Access to agricultural trainings and extension services

X_{10}= use of mineral fertilizers (TFert)

X_{11}= Livestock Ownership (LO)

β_0 was a constant term, βi were the parameters to be estimated   i=1.......7

ε_i= error term

3.5.2.1. Performance Measures

The analysis of the model used three performance measures:

1)   P-value: this is a significance statistic test. It is normally tested at a threshold value of 1%, 5% and 10%. If the p-value is less than the threshold value, the null hypothesis is rejected and accept the alternative hypothesis. For our model, we tested at 1%, 5% and 10% level of threshold. Therefore, if the p-value was less than 1%, 5% and 10% we concluded that the hypothesis was statistically significant or valid.

2)   B-value: the beta coefficients show the effect of the independent variables on the dependent variable. A positive coefficient for β indicates a positive impact while a negative coefficient indicates a negative impact. For our analysis, a positive β value showed that the independent variable was more likely to impact the dependent variable to be in a given better off category with respect to the reference/base category and a negative β value showed that the independent variable was less likely to impact the dependent variable category under consideration with respect to the reference category. If β=0, the particular category and the reference category are equally likely to be impacted by the independent variable.

3)   Exponential Beta Value: this value gives us the odds ratio for the independent variables. It is an exponentiation of the coefficients (βi). The odds ratio shows the change in odds of the dependent variable being in a particular category compared to the reference category. An odds ratio greater than 1 indicates that the probability of the outcome falling in the comparison group relative to the probability of the outcome falling in the referent group increases as the variable increases. Therefore, it is more likely to fall in the comparison group. An odds ratio less than 1 indicates that the probability of the outcome falling in the comparison group relative to the probability of the outcome falling in the referent group decreases as the variable increases. It is less likely to fall in the comparison group.

4. Results and Discussions

4.0. Introduction
Based on the study objectives, the results and their interpretations are presented under the following sections: The first section deals with the descriptive statistics, providing the profile of sampled respondents based on the salient demographic, economic and institutional factors which in the conceptual framework of the study were hypothesized to influence the household food security status of the smallholder farmers (Figure 3). The second section categorizes the sampled smallholder farmers' households per different levels of experienced food insecurity. The third section presents the diagnostic tests for econometric problems including the correlation and multi-collinearity tests. The forth section presents the results of multinomial logistic regression models, assessing the effect of each of the hypothesized demographic and resource factors on food security status of the smallholder farmers.

4.1. Descriptive Statistics
The first objective of this study was to describe the socio-demographic and resource characteristics of the smallholder farmers in Burera district. To achieve this objective, the descriptive analysis was performed on key profile variables and outputs are presented in this section.

4.1.1. Socio-Demographic Profile of Respondent Smallholder Farmers
The results in Table 2 provide a profile picture of the respondents in terms of household demographic characteristics. Out of the 378 smallholder farmers' households sampled, 66.1% had a family size of less than 5 members, while 33.9% had 5 and more family members. The mean of family size among respondents was 4.5 members. The dependence ratio was over one for 26.5% of respondents' households. Most of the sampled households (73%) were male headed; only 27% were headed by females. Regarding the marital status of the household head, it was found that 90.2% were couple, 1.9% adult single males and 7.9% adult single females. It was also found that 52.9% of sampled household heads had never attended school, while 43.1% had only been in primary school. Only 3.9% had been at the level of high school. Looking at all the household members' education level, 67.5% of the sampled households had at least one family member who attended primary school level and only 6.6% had a member who ever reached high school level of education.

(a)   Family size and farm-holder dependents
While the current study found that the majority (66.1%) of sampled smallholder farmers' households had less than 5 members with average family size of 4.5 members, the 2010/2011 EICV3 (NISR, 2011) had indicated that the mean number of household members in Burera district was 5 persons per family which used to be above the national average of 4.8 members per household. This remarkable difference from 2011 to 2016 might be attributed to the mindset change as more sensitization on family planning has been happening across the country to be able to decelerate the population growth in Rwanda. Similar trend of decreasing family size is also observed nation-wide, as the EICV4 of 2013/2014 (NISR, 2015) revealed that the national mean of household members had reduced from 4.8 in 2010 to 4.6 in 2013. The 2017 Rwanda Demographics Profile done by Index Mundi also confirmed that the average number of births per woman decreased from a 5.6 in 2005 to 4.5 in 2016 (Index Mundi, 2017).

The average family size among the sampled smallholder farmers of Burera district is lower compared to the general trend observed among smallholder farmers across the globe. Comparing the economic lives of smallholder farmers across nine countries, FAO found that the average family size of smallholder farmers is generally large, and in countries like Kenya and Bangladesh, the average is 7 members from which at least 2 members are of age less than 14 years (Rapsomanikis, 2015).

Also, the results showed lesser number of households with high dependency ratio (more than 1, which means that in the household there are more dependents than active members able to work and feed the family), which could be associated to the average family size. The majority of the smallholder farmers' households in Burera district have a balanced ratio between

the sum of children and elderlies considered as dependents to be fed and the household members in active age relied on to feed the family. However, this is different from other districts of the country, like Eastern province where the proportion of households with higher dependency ratio (over one) was found to be up to 46% in Kayonza district (Nsabuwera V et al., 2015).

Variable		Frequency	Percent
	Total	**378**	**100**
Family Size*			
	Less than 5 members	250	66.1
	Between 5 and 8 members	116	30.7
	More than 8 members	12	3.2
Household Dependency ratio**			
	≤1	278	73.5
	>1	100	26.5
Education level of the household head			
	Never attended school	200	52.9
	Attended primary level	163	43.1
	Attended secondary level	13	3.4
	Attended University level	2	.5
Summed education level of household members			
	No member attended school	93	24.6
	At least one member attended Primary	255	67.5
	At least one member attended secondary	25	6.6
	At least one member attended vocational training	5	1.3
	At least one member attended university	0	0
Gender of the household head			
	Female	102	27.0
	Male	276	73.0
Marital status of the Household head			
	Couple (Husband &wife)	341	90.2
	Adult male, no wife	7	1.9
	Adult female, no husband	30	7.9
	Child headed (<18 years)		
Age of the Household head			
	18-45years	216	57.1
	46-65years	114	30.2
	66-75years	29	7.7
	76 and more	19	5.0
*The mean number of family members was 4.5 **The household dependency ratio is equal to (n<16 years + n>65years)/n(16–65 years).0 = no dependents, 1=as many dependents as non-dependents, >1= more dependents than non-dependents.*			

Table 2: Households Socio-demographic characteristics of the sampled smallholder farmers in Burera District

(b) Gender of the household head

Regarding gender of the household head, it was not surprising to find that the majority of sampled households were male-headed. In the Rwandan context with paternal culture, the household would be only headed by female if she is a widow or separated. The trend of marital status of the household head was as expected, with the majority being married couple (husband and wife).

In the past few years, due to the tragic history of genocide which left many orphans, it was also common to find cases of child headed households country wide (the elder child who looks at his siblings being below 18 years old), however this case was not found in the sampled respondents, which is also a good sign that the Rwandan society is maturing and recovering from the sequels of the genocide.

(c) Education level of the sampled smallholder farmers

Education level among the smallholder farmers of Burera district was found to be very low, the majority of household heads are illiterate, while at household level the trends is a bit changing, with more members having a primary school education, though high school attendance is still limited. This reflects the reality of the Rwandan rural settings where most of

the households live on the subsistence farming and used to drop children from school for the farm house labor. However, the trend is changing nowadays with the education policy enforcement which stipulates that every child in schooling age should attend school, with free access to 9-year basic education (MINEDUC, 2008). However other countries have shown higher trends of education level of smallholder farmers, like the findings of FAO in the Caribbean where data of 1999 showed that 50-55% of smallholder farmers had achieved primary level and 20 % had completed Secondary level of education (Graham B, 2012).

(d) Age of the household head
The study found that 57.7% of smallholders' household heads were aged between 18years and 45, while 30.2% had age between 46 and 65 years. Only 12.7% were aged beyond 65 years. The mean age of the household heads was found to be 44.8 years. The fact that the majority of the household heads were in the early active age (below 45 years) aligns with the national demographics which states that 51.8% of Rwandan population are between 15 years and 55 years (Index Mundi, 2017). It also aligns with the EICV3 findings which stated that in 2010/2011, in Burera district the majority of population (81%) was young, aged below 40 years old.

4.1.2. Resource Characteristics of the Smallholder Mixed Farmers in Burera District
The Table 3 presents the resource characteristics of the sampled smallholder farmers.
(a) Farm size
The results show that the majority of the smallholder farmers in Burera district operate on small plots of land, with 77.7% of the respondents having less than 1ha of land, 50.5% owning between 0.5 and 1 ha, while 27.2 % lived on less than 0.5 ha of land.
The findings of this study confirmed what the 2010/2011 Rwanda EICV3 had found out while profiling Burera district. It stated that over 80% of Burera population lived on agriculture and 91.3% of households operated on land less than 0.9ha, with a mean of 0.39ha (NISR, 2011). The small size of land has been the main characteristics of smallholder farmers across the World. Rapsomanikis (2015) of FAO, in his work of assessing the economic lives of smallholder farmers with household data from 9 countries, stated that *"Smallholder families live in farms which in many countries are significantly smaller than 2 hectares"*. The average size of smallholder farm in Bangladesh and Vietnam is 0.24 and 0.32ha respectively, Average smallholder farm in Kenya and Ethiopia is 0.47ha and 0.9ha respectively. Only in Latin American countries, smallholder farmers often tend to be over 2 hectares, up to 5hectares (Rapsomanikis , 2015). The average small size of farms on which the smallholder farmers of Burera district operate and live on was hypothesized in this study to be a predictor of household food insecurity. This hypothesis is tested with inferential statistics below.
(b) On-farm income
Regarding the average annual income from the farming activities, 41.3% of respondents earn less than 200.000 FRW (less than 250 USD with exchange rate of 800FRW/1US$), 42.9% earn between 200.000 and 300.000 FRW (250-400 USD), while only 15.9% could earn above 300.000 FRW (400 USD). If we translate the estimated annual revenues from farming activities to daily rate, the majority of the smallholder farmers (84.2%) in Burera district would be living on income below the internationally set poverty line of 1.25 USD/day (World bank, 2005), which has been adjusted to 1.9 USD/day considering Power Purchasing Party Exchange rates of 2011 (World Bank, 2011). That means that the majority of the smallholder farmers in Burera district are classified as poor. The findings of the study on the ranges of annual income for these smallholder farmers align with the findings of the 2013/2014 EICV4 (NISR, 2015) which stated that at the national poverty line threshold of 159,375 FRW (227.6 USD[1]) annual household total consumption, about 39.1% of the Rwandan population are identified as poor. In 2011/2012, EICV3 had set a threshold of poverty line at 118,000 FRW per year, that is 194 USD/ year at exchange rate of 607FRW/ 1USD (NISR, 2011). This EICV3 had found Burera district as the first among districts in the range of 40-55% of population identified as poor (NISR, 2011).

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[1] Average Exchange rate of 700 FRW per one USD

Variable		Frequency	Percent
	Total	*378*	*100*
Farm size (ha)			
	≤ 0.5 ha	103	27.2
	Between 0.5 and 1ha	191	50.5
	More than 1ha	84	22.2
On Farm Income (FRW/ annum)			
	≤200,000	156	41.3
	Between 200,000 and 300,000	162	42.9
	Above 300,000	60	15.9
Livestock ownership			
	Own at least one livestock (cow, goat, sheep or pig)	145	38.6
	Own at least one cow	60	15.9
	No livestock	173	45.5
Onfarm labor availability			
	Less than 3 active members	284	75.1
	Between 3 and 4 active members	83	22
	More than 4 active members	11	2.9

Table 3: Resource characteristics of the sampled smallholder farmers in Burera District

Similar trend of low income from the farming activities for smallholder farmers which leads them to be classified as poor is recognized across many countries. In Bolivia, up to 83% of smallholder farmers are classified as poor as well within the national poverty average of about 61%; in Ethiopia, poverty headcount ratio of smallholders is 48% and in Vietnam more than a half of the smallholder farmers are poor (Rapsomanikis , 2015). Although there is association between land size and on-farm annual income obtained, the land productivity factor is equally important and smallholder farmers of Burera district should optimize that. For instance, it has been shown that a smallholder farmer in Bangladesh operating on 0.24 ha of land can generate about 2.9 US$ per person per day which is very different from the counterpart smallholder farmers in African countries (Rapsomanikis , 2015).

To cope with the low revenues of farming activities, the respondent smallholder farmers of this study confirmed that to they try to diversify their income sources. Only 39% confirmed that they solely live on farming activities on their land, while 55% combine farming on their own farms with casual jobs (either working on others farms or other daily paying jobs), 6% combine farming with small businesses and crafts. Thus, boosting revenues and the living conditions of smallholder farmers should combine both a boost in capital assets (land and livestock), but also in the skills-mix which gives rise to diverse sets of opportunities in the rural non-farm sector. Kenya is a typical example, where smallholder farmers, in combination with work on their land and a multiplicity of off-farm jobs, earn a gross income of about 2,527 USD per year, making about 1.4 USD per day per person in a family of average size of 5 members (Rapsomanikis , 2015).

(c) Livestock assets

The study found that 54.2% of the sampled smallholder farmers owned at least one livestock (either cow, goat, sheep or pig) that helped to produce organic manure, with only 15.87% having cows in their households. The importance of livestock assets in the smallholder mixed crop farming cannot be emphasized more. It is the main source of organic manure, but also it represents a "saving account", providing an economic security against frequent failure (Njarui et al, 2016). The findings are slightly different from the EICV3 which had stated that in Burera district 78.5% of all households were raising some type of livestock in 2010/2011 while the national proportion was 68.2% (NISR, 2011). However, the findings could be accurate as only medium to large livestock were counted in the study (cows, sheep, goat, pig) while the EICV had counted even small animals as chickens, rabbits and others. The findings of the study align with the proportions reported in EICV4 (NISR 2015) which stated that in Northern Province 31.5% of household's rear sheep; 37.6 % rear goats; 28.1% rear pigs. The big difference is on cattle rearing where EICV4 reports that in Northern Province 57.8% of households' rear cattle, while the findings of this study were 15.8% among the smallholder farmers.   However, given the high levels of income poverty among the sampled smallholder farmers, it is also likely the 15.8% cattle owned could be from the overall 6.8% share of the Northern Province from the "One Cow Per family" Policy as reported by EICV4 (NISR,2015).

(d) On-Farm House labor

About the availability of labor resource factor, 31.2 % of the sampled households had only one member in active age who could be relied on to supply labor, 45.8% had 2 active members while 23% had more than 2 active members catering for the household. This means that 75.1% of the households could only rely on the household head alone or his wife, not many other family members available to support in on –farm activities. This is also reflective of the discussion above regarding the age of the household head: if 57.7% of the household heads were aged below 45 years old, and considering that the age of

marriage in Rwanda is set at 21 years, that means most of the households sampled were having young children of less than 16 years and considered to be still in schooling age.

Although the current findings show that the majority of the sampled smallholder farmers households have a limited number of on-farm labor (with 75.1% having less than 3 active members), given also the statement of WFP in its 2012 and 2015 CFSVA (WFP, 2012 &2015) that rural households with few adult household members tend to be food insecure, this study agrees with Rapsomanikis (2015) who found that the number of family workers does not tell the whole story. He continued stating that smallholder farmers typically exploit very low capital to labour ratios, using more labor than capital resources (like land) to produce food. From the FAO's data set from 9 countries, he found that in Kenya, Bolivia and Albania, the family labor amounted to 2; 2.5 and 3.2 persons per day and per hectare respectively. Rapsomanikis (2015) concludes that small farms over-use family labour, meaning that they use it more than a level that would be consistent with profit-maximization.

4.1.3. Access to Institutional Support for the Smallholder Farmers in Burera District

Access to agricultural extension services and financial services were also assessed as factors that influence the farm productivity (knowledge on farm practices) but also investment capital (savings and loans). Data presented in Table 4 show that only 8% of the respondents had received agricultural training or extension assistance within the one-year period from the date of interview. The main extension service provider cited by trained respondents (58.6%) was the sector agronomist/ veterinary (public extension agent covering more than 6000 households that comprise the administrative sector boundary). Financial literacy among the smallholder farmers and access to financial facilities are also very limited, only 28% of the respondent had some mechanisms of saving and accessing to loans, among them 20% were using informal savings and lending groups of neighbors (IBIMINA), while only 8% were using the formal Saving and Credit Cooperative (SACCO) available at sector level. None of the respondents had ever acquired loan from any bank. The limited access to extension services spanned to the limited level of using improved farming techniques which should include the use of mineral fertilizers with the Government subsidies. Only 25% respondents had used mineral fertilizers at least in the previous 2 agricultural seasons preceding the time of interview, that is either during season A of September 2016 or Season B of March 2016. Another stimulating factor to easily access extension services in rural areas is being a member of agricultural cooperative, where extension officers can easily reach the cooperative members at their gatherings and bank loans can be provided on a group guarantee. Although 44% of the respondents said they were members of a cooperative, only 6% were members of registered cooperatives with agricultural production purposes, 8% being members of informal savings and lending groups (IBIMINA) in their neighborhood, and 30% being members of informal unregistered cooperatives of social assistance, mainly exchanging labor during the planting season.

The findings on access to financial and agricultural extension services were not of a surprise, actually this study confirmed the general trend across the world: In 2014, IFC reported that while agriculture remains a key economic activity in Africa employing about 55% of population, only approximately 1% of bank lending goes to agricultural sector. Furthermore, only 4.7% of adults in rural areas in developing countries globally have a loan from a formal financial institution and only 5.9% have a bank account (IFC, 2014). Although the 2016 FinScope Rwanda reported 89% of adult population in Rwanda to be financially included (through formal and informal financial services), 72% of them use informal mechanisms, and Burera district accounts 87% of its adult population using informal financial mechanisms. The current study results on access to finance among the smallholder farmers align very well with the found situation in Zambia where FinScope 2015 found that among smallholder farmers, only 16.9% of farmers used formal services and 23.3% used informal services which include informal rotating savings schemes, structured saving groups and or informal credit providers (Mercy Corps, 2016).

Variable		Frequency	Percent
	Total	*378*	*100*
Access to financial facility (loans, saving)			
	No	273	72
	Yes	105	28
Used mechanisms of saving and borrowing money			
	Informal saving groups (Ibimina)	73	19.3
	SACCO	32	8.5
	MFI/ Bank	0	0
Received agriculture training /extension assistance in last year			
	No	349	92
	Yes	29	8
Belonging to agricultural Cooperative			
	No	212	56
	Yes	166	44
Use of mineral fertilizers			
	Did not use fertilize in last 2 seasons	283	75
	Did use fertilizer in last two seasons	95	25

Table 4: Access to institutional facilities for the sampled smallholder farmers in Burera District

Regarding access to agricultural trainings and extension services, it was not also surprising to find very low levels given that in Rwanda the decentralized public extension services depend solely on only one sector agronomist and one veterinary who have to plan for agri seasons, ensure inputs are delivered in the sector, attend trainings and then supervise the run of agricultural season cycle from planting to harvests. It can be easily understood that he will not be able to reach smallholder farmers households, rather he will focus on few large-scale farmers and cooperative lands where he can demonstrate his performance, both in terms of land use consolidation and production. Thus, the smallholder farmers are left to their fate and guess.

The limited access to extension services is with no doubt linked to the low level of use of chemical fertilizers, despite the Government efforts to boost use of fertilizers, including subsidies. The 2015 Rwanda Poverty profile drawn from EICV4 indicated that nationwide, purchasing of chemical fertilizers was at 36.4% accounting for all small and large-scale farmers. Thus, the low level of fertilizer users (25%) conforms to the national trend.

4.1.4. Determining the Food Security Status of the Smallholder Farmers of Burera District

The second objective of this study was to assess the smallholder farmers' experience of food insecurity situations and therefore to categorize each household according to the household food insecurity access score. The HFIAS tool (appendix1) categorizes households into four levels of food security status which are food secure, mildly food insecure, moderately food insecure and severely food insecure. The frequencies of responses to the 9 questions of HFIAS tool are presented in Table 5, while the results of the analyzed categories of food security status are presented in the Table 5 below.

The results in Table 5 show that the frequencies of responses varied across the 9 questions of HFIAS tool which reflect 3 domains of experience for the household: stated anxiety and uncertainty about food; household experience with the quality of food (limited varieties and unmet preferences) and the experience with insufficient food intake (quantity of food consumed). About the anxiety and uncertainty about food, 58% of the respondent smallholder farmers had been worried for some time or so often about access to enough food; 45% felt they had eaten so often the kinds of food they did not prefer because of lack of resources; 60% experienced so often a situation of eating few kinds of food (limited varieties) while even 62% confirmed that it happened so often to eat kinds of food that they should not eat but due to limited means they had to. However very few (10%) expressed that it has sometimes happened to miss food at all in their households, though still 28% experienced a situation of sometimes going to sleep feeling hungry because there was not enough food. Though it might be exaggerated, 5% expressed that it rarely happened to go a whole day and night without eating anything.

	Variable (HFIAS Questions)		Frequency of Occurrence				Total
			Never	Rarely	Sometimes	So often	
1	Did you worry that your household would not have enough food?	n	98	60	156	64	378
		%	26%	16%	41%	17%	100%
2	Were you or any household member not able to eat the kinds of food you preferred because of lack of resources?	n	55	51	102	170	378
		%	15%	14%	27%	45%	100%
3	Did you or any household member eat just a few kinds of food day after day due to lack of resources?	n	71	12	69	226	378
		%	19%	3%	18%	60%	100%
4	Did you or any household member eat food that you preferred not to eat because of lack of resources to obtain other types of food?	n	40	22	80	236	378
		%	11%	6%	21%	62%	100%
5	Did you or any household member eat a smaller meal than you felt you needed because there was not enough food?	n	90	40	81	167	378
		%	24%	11%	21%	44%	100%
6	Did you or any household member eat fewer meals in a day because there was not enough food?	n	171	78	103	26	378
		%	45%	21%	27%	7%	100%
7	Was there ever no food at all in your household because there were not enough resources to get more?	n	304	36	37	1	378
		%	80%	10%	10%	0%	100%
8	Did you or any household member go to sleep at night hungry because there was not enough food?	n	38	213	104	23	378
		%	10%	56%	28%	6%	100%
9	Did you or any household member go a whole day without eating anything because there was not enough food?	n	358	18	2	-	378
		%	95%	5%	1%	0%	100%

Table 5: Assessment of smallholder farmers experience with food insecurity situations

The results in Table 6 show that out of 378 smallholder farmers' households interviewed, only 24 households representing 6.3% were found to be in the category of food secure representing, 59 were mildly food insecure (15.6%), while 131 were moderately food insecure (34.7%) and 164 were severely food insecure (43.4%). The results showed that there is a big proportion of smallholder farmers living in a situation of food insecurity, with only 6.3% of the sample not being worried about food availability and access.

	Food security Status	Frequency	Percent	Cumulative %
1.	Food Secure	24	6.3	6.3
2.	Mildly Food Insecure	59	15.6	22.0
3.	Moderately Food Insecure	131	34.7	56.6
4.	Severely food Insecure	164	43.4	100.0
	Total	378	100.0	

Table 6: Food security status of sampled Smallholder farmers of Burera District

The mildly and moderately food insecure households representing 50.3% are sometimes considered as marginally food secure households with transitional food security status given that at normal harvests they become fully food secure and may face transitory food insecurity if the harvest is poor (WFP,2012). In the contrary, the severely food insecure households are those that face food deficit all year long and are in situation of almost chronic food insecurity.

The results showed that, as we move from food secure category to severely food insecure category the level or percentage of household increases. This indicates that in the study area, even though many efforts have been done by the Government of Rwanda, the number of households who are severely food insecure is still high and therefore calls for redefining strategies for rural extreme poverty immediate interventions. The findings confirmed the findings of the WFP's Rwanda 2015 comprehensive food security and vulnerability analysis (WFP, 2015) which had found that though food is generally available in markets and well –developed infrastructure allows food to move across the country, in response to the question whether households had enough food or money to purchase it, 50% of the surveyed Rwandan households expressed that they had had difficulties in accessing food at some point in the previous year. Using a different categorization method of food security index, that WFP assessment had classified Rwandan households in general as 40% being food secure; 40.2% of the households as marginally food secure, living with stress in coping strategies to food insecurity, while 16.8 and 2.6% classified respectively as moderately food insecure and severely food insecure are those households with livelihood coping strategy in crisis and in emergency. Despite the differences in classifications, we assume the sampled smallholder farmers fall in that category considered by WFP as marginally food secure living with some sort of stress to cope with food accessibility. According to the answers provided to the 9 HFIAS questions (Table 5), only 5% of the respondents had rarely ever spent a day and night without eating, meaning that the study respondents were out of the crisis and emergency cases.

It was not also surprising to find very low proportions of food secure households among the smallholder farmers, given that the same WFP studies (WFP, 2012 &2015) had found that food insecurity is prominent in the low-income agriculturists who represent the most common livelihood type in Rwanda. The same studies had also suggested that when compared to food secure households, food insecure households have less livestock, less agricultural land, fewer adult household members, grow fewer crops and mostly consume more of their own production at home. This has been demonstrated by the logistic regression of this study, which showed that livestock asset and land size significantly affect the status of the household food security of the smallholder farmers.

The findings of this study on social –economic determinants of food security among the smallholder farmers using HFIAS tool found similar trends of food insecurity in rural area aligned with other studies in other rural areas of Africa, like Patrick S. (2012) who worked on the determinants of food accessibility of rural households in the Limpopo province, South Africa and found that 53% were severely food insecure using the same tool. The results are also in line with the study of Hiwot (2014) who found that about 10.16% of households were food secure, 11.07% were mildly food insecure, 22.76% were moderately food insecure and 56.01% were severely food insecure. On the other hand, food security trend observed in the smallholder farmers of Burera was different from the findings of Ame, et al. (2016) who assessed the household food security through crop diversification in Magway region of Myanmar. They found that 31.25% were households food secure, 35% were households mildly food insecure, 25% were households moderately food insecure and 8.75% were households severely food insecure. Ame et al (2016) found that the majority of the sampled farmers were found to be in the category of household mildly food insecure followed by household's food secure, a trend which is different from the present study. The differences in findings among the smallholder farmers could be explained by the social and economic context of the two countries, Rwanda and Mynmar.

4.2. Inferential Statistics: Econometric Analysis of the Determinants of Household Food Security

The third and fourth objectives of this study were to determine the effect of resource factors combined with the socio-demographic factors on the food security status of the smallholder farmers 'households. Resource factors considered included the operated farm size, estimated on-farm income per annum, livestock assets, type of fertilizer used and farm-house labor availability, that is the number of physically active members of the household (within legally accepted age limit for labor provision). In Rwanda, children are considered to be mature to work at age of 16 years, while the retirement age is set at 65 years though this doesn't limit those children or elders could contribute to farm labor provision as there is no rule against that. Demographic variables factored in the analysis included age, gender and education of the household head and family size or fam-holder dependents. Institutional mechanisms were also factored in as intervening variables such as availability and access of agricultural trainings and extension services as well as access to financial services for capital saving and equity loans acquisition.

Before carrying out the multinomial logistic regression of the above parameters to find association odds ratios, diagnostic tests were performed to assess correlation and potential multi-collinearity among the hypothesized parameters.

4.3.1. Multi-Collinearity Diagnostic Test

Assumption 10 of the classical linear regression model (CLRM) is that there is no multi-collinearity among the regressors included in the regression model (Gujarati, 2004). Estimating a model in the presence of multi-collinearity leads to get the indeterminate regression coefficients (i.e. the coefficients cannot be estimated with great precision or accuracy) and their standards errors are infinite. In this section we take a critical look at this assumption. Multi-collinearity was checked by Pearson bivariate correlation matrix, tolerance statistics and variance inflation factor(VIF). As Gabriella (2016) suggested, a tolerance value of less than 0.01 indicates serious collinearity problems. Gabriella (2016) argued also that if any of the VIF value exceeds 5 (the cut-off point) that variable which has that value is the cause of Multi-collinearity. Multi-collinearity problem arises when some or all the explanatory variables are highly correlated. Thus, estimating a model in the presence of multi-collinearity reduces the precision of estimation. Multi-collinearity is occurred when there is poor sampling method, misspecification and overfitting of a model as well as improper use of dummy variables (Gujaratti, 2004). Bivariate correlation matrix of the explanatory variables, variance inflation factors (VIFs) and tolerance are some of the statistical techniques that have been provided for detecting multi-collinearity among categorical variables. For the purpose of the present study these three techniques will be employed. Even though these techniques have the same purpose of testing multi-collinearity, they differ in the levels in which they are used. Pearson Bivariate correlation matrix is used to help detect high multi-collinearity between predictors (X_i and X_j, i≠j). VIFs are used to investigate potential multi-collinearity problems.

$$VIF(\widehat{\beta}) = \frac{1}{1 - R_j^2}$$; Where R_j^2 is the coefficient of determination obtained when Xj is regressed on the remaining ρ-1

predictors. The VIF of each predictor in the model measures the combined effect of the dependencies among the predictors on the variance of that predictor.

Multi-collinearity is confirmed if any of the VIFs exceeds 10. Another way of detecting the multi-collinearity is to take the inverse of VIF named as tolerance. And when tolerance is less than 0.01 then the variable is to be eliminated from the model because it causes the multi-collinearity. In order to diagnose the multi-collinearity among the regressors, results of Pearson Bivariate correlation matrix, VIFs and tolerance are given in the Table 7.

4.3.1.1. Correlation Matrix

Correlation analysis measures the degree of relationship between the independent variables under consideration. It enables us to have an idea about the degree and direction of the relationship between the two variables under consideration. As suggested by Gabriella (2016), it is essential to diagnose the existence of multi-collinearity among the regressors. The results of the Pearson's correlation matrix in the Table 7 revealed that none of the Bivariate correlation between any two regressors exceed 0.8 meaning that multi-collinearity is not a problem and then all the regressors are to be included in the model.

		Gender of the household head	Education of the household head	On Farm Income	Farm size	Training in Agriculture and food security	Access to financial services	Family Size	Farm house labour
Gender of the household head	Pearson Correlation	1							
	Sig. (2-tailed)								
	N	378							
Education level of the household members	Pearson Correlation	.036	1						
	Sig. (2-tailed)	.480							
	N	378	378						
On Farm Income	Pearson Correlation	-.016	.047	1					
	Sig. (2-tailed)	.757	.360						
	N	378	378	378					
Farm size	Pearson Correlation	-.061	-.027	-.126*	1				

		Gender of the household head	Education of the household head	On Farm Income	Farm size	Training in Agriculture and food security	Access to financial services	Family Size	Farm house labour
	Sig. (2-tailed)	.240	.604	.014					
	N	378	378	378	378				
Training in Agriculture and food security	Pearson Correlation	.041	.017	.033	-.121*	1			
	Sig. (2-tailed)	.428	.735	.522	.019				
	N	378	378	378	378	378			
Access to financial services	Pearson Correlation	-.022	.128*	.039	.087	-.023	1		
	Sig. (2-tailed)	.667	.013	.453	.093	.650			
	N	378	378	378	378	378	378		
Family Size1	Pearson Correlation	.009	.023	.031	-.062	.041	.012	1	
	Sig. (2-tailed)	.869	.659	.547	.229	.424	.815		
	N	378	378	378	378	378	378	378	
Farm House Labour	Pearson Correlation	.039	-.037	.034	-.057	-.001	.021	.392**	1
	Sig. (2-tailed)	.449	.478	.509	.267	.983	.680	.000	
	N	378	378	378	378	378	378	378	378
*. Correlation is significant at the 0.05 level (2-tailed).									
**. Correlation is significant at the 0.01 level (2-tailed).									

Table 7: Correlation matrix of the variables in the model

4.3.1.2. Collinearity Analysis

Table 8 shows the result of variance inflation factor. It is seen from the table that the values of VIFs for all the explanatory variables are less than 5 meaning that multi-collinearity is not a problem. It can be also seen that the values of tolerance are greater than 0.01 meaning that the regressors in question are not correlated.

Model		Collinearity Statistics	
		Tolerance	VIF
	Use of fertilizers	.178	5.606
	Livestock Asset	.922	1.084
	Farm House Labor	.773	1.293
	Age of the household head	.834	1.199
	Gender of the household head	.979	1.021
	Education of the household head	.920	1.087
	On Farm Income	.945	1.058
	Farm size	.934	1.071
	Access to financial facility	.958	1.043
	Training in Agriculture and food security	.176	5.679
	Family Size	.771	1.297
a. Dependent Variable: Food Security Status1			

Table 8: Collinearity diagnostic test

4.3.2. Multinomial Logistic Regression

4.3.2.1. Model Testing with All Initial Estimated Parameters.

Based on the procedures of the multinomial logistic model, the model fitting information and maximum likelihood parameter estimates for the model were computed (Table 9 and Table 10). The coefficients (βi) of the independent variables in the model were studied and assessed with respect to a priori expectations of the signs and the statistical significance of the coefficients. The multinomial logistic model has been applied to describe the main objective of the study. That is, to find out the important variables that influence smallholder farmers' household food security in Burera district. The results of the logistic regression model are presented in the Table 11 below.

Model Fitting Information				
Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	882.936			
Final	194.129	688.808	33	.000
Pseudo R-Square				
Cox and Snell	.838			
Nagelkerke	.923			
McFadden	.763			

Table 9: Econometric Model Fitting

Table-9 describes the model fitting information. In the multinomial logistic regression model, dependent variable is status of household food security and independent variables are Household Age, Gender, education, family size, farm size, livestock asset, on farm income, farm house labour, use of fertilizer, access to financial facility and access to training. The first model is called null model (model with intercept only) and the second model is alternative model (model which includes all the independent variables). To compare the difference between these two models, there is a need to make a statement of the hypothesis to be tested:

H_0: There is no significant difference between null model and final model

H_1: There is significant difference between null model and final model

The results showed that sig value or p-value (0.000) is less than 0.05; it means that the null hypothesis is rejected and favors the alternative hypothesis. Therefore, it is concluded that there is significant difference between null model and final model in other words the final model is fit (independent variables impact the status of food security). The pseudo R-Square showed that the independent variables influence the dependent variable up to 92% level.

Effect	Model Fitting Criteria	Likelihood Ratio Tests	
	-2 Log Likelihood of Reduced Model	Chi-Square	Sig.
Intercept	1.941E2	.000	0.
AgHH	718.547	524.418	.000
Educ	2.036E2	9.472	.024
OnFI	2.490E2	54.872	.000
FS	1.954E2	1.244	.742
FMS	1.973E2	3.126	.373
FHL	1.947E2	.604	.896
AT	1.976E2	3.473	.324
AFF	2.074E2	13.317	.004
Gen	2.177E2	23.547	.000
TFert	196.015	1.886	.596
LA	2.038E2	9.644	.022

Table 10: Likelihood Ratio Tests

Table 10 explains the likelihood ratio.

Chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model.

H_0: All the parameters (βi) are equal to zero/ there is no significant difference between reduced model and final model

H_1: some or all the parameters are not equal to zero/ there is significant difference between reduced model and final model.

The results revealed that among 11 independent variables, 6 variables such as age of the household head, education level, gender of the household head, on farm income, livestock asset and access to financial facility are having significant impact on the status of household food security (p-value<0.005).

It means that the null hypothesis is rejected and favors the alternative hypothesis. Therefore, it is concluded that there is significant difference between reduced model and final model. in another word their respective parameters are different from zero.

Food Security Status1[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
Food Secure	Intercept	-18.894	812.584	.001	1	.981			
	AgHH	-2.696**	1.123	5.758	1	.016	.068	.007	.610
	Educ	.081	.648	.016	1	.900	1.085	.305	3.860
	OnFI	5.278***	1.543	11.696	1	.001	5.956	9.517	4034.540
	FS	-.082	.589	.020	1	.889	.921	.290	2.920
	FMS	-1.825	1.189	2.357	1	.125	.161	.016	1.657
		-.646	.956	.457	1	.499	.524	.080	3.413
	[TA=.00]	8.891	812.579	.000	1	.991	7263.775	.000	.b
	[TA=1.00]	0c	.	.	0	.	.	.	.
	[AFF=1.00]	-2.757**	.954	8.342	1	.004	.064	.010	.412
	[AFF=2.00]	0c	.	.	0	.	.	.	.
	[Gen=.00]	.971	.973	.998	1	.318	2.642	.393	17.771
	[Gen=1.00]	0c	.	.	0	.	.	.	.
	[TFert=.00]	1.721	.000	.	1	.	5.593	5.593	5.593
	[TFert=1.00]	0c	.	.	0	.	.	.	.
	[LA=.00]	1.824*	.944	3.732	1	.053	6.195	.974	39.402
	[LA=1.00]	0c	.	.	0	.	.	.	.
Mildly Food Insecure	Intercept	-170.936	720.827	.056	1	.813			
	AgHH	52.960	236.984	.050	1	.823	1.000E23	1.903E-179	5.259E224
	Educ	-3.825**	1.560	6.010	1	.014	.022	.001	.464
	OnFI	1.205*	.723	2.779	1	.095	3.337	.809	13.762
	FS	.052	.644	.006	1	.936	1.053	.298	3.721
	FMS	.042	.872	.002	1	.961	1.043	.189	5.759
	FHL	.378	1.053	.129	1	.720	1.459	.185	11.491
	[AT=.00]	-25.535	3666.589	.000	1	.994	8.133E-12	.000	.b
	[AT=1.00]	0c	.	.	0	.	.	.	.
	[AFF=1.00]	.698	1.053	.439	1	.508	2.009	.255	15.828
	[AFF=2.00]	0c	.	.	0	.	.	.	.
	[Gen=.00]	17.301	106.210	.027	1	.871	3.264E7	1.282E-83	8.309E97
	[Gen=1.00]	0c	.	.	0	.	.	.	.
	[T Fert=.00]	25.985	3666.590	.000	1	.994	1.928E11	.000	.b
	[T Fert=1.00]	0c	.	.	0	.	.	.	.
	[LA=.00]	-2.750*	1.470	3.496	1	.062	.064	.004	1.142
	[LA=1.00]	0c	.	.	0	.	.	.	.
Moderately Food Insecure	Intercept	-42.228	355.440	.014	1	.905			
	AgHH	21.349	177.716	.014	1	.904	1.869E9	9.989E-143	3.498E160
	Educ	-.618	.435	2.023	1	.155	.539	.230	1.263
	OnFI	.285	.347	.674	1	.412	1.330	.673	2.628
	FS	-.304	.341	.795	1	.373	.738	.378	1.439
	FMS	-.287	.437	.432	1	.511	.750	.318	1.767
	FHL	.051	.444	.013	1	.909	1.052	.440	2.513
	[AT=.00]	-11.387	125.863	.008	1	.928	1.134E-5	8.307E-113	1.547E102
	[AT=1.00]	0c	.	.	0	.	.	.	.
	[AFF=1.00]	-.276	.526	.275	1	.600	.759	.271	2.128
	[AFF=2.00]	0c	.	.	0	.	.	.	.
	[Gen=.00]	.340	.486	.490	1	.484	1.405	.542	3.640
	[Gen=1.00]	0c	.	.	0	.	.	.	.
	[TFert=.00]	10.500	125.867	.007	1	.934	36330.182	2.643E-103	4.993E111
	[TFert=1.00]	0c	.	.	0	.	.	.	.
	[LA=.00]	-.179	.455	.155	1	.693	.836	.343	2.039
	[LA=1.00]	0c	.	.	0	.	.	.	.

Table 11: Multinomial logistic regression Estimates with 11 independent variables

Number of observations: 378, Wald Chi^2 (33): 688.808; Prob=0.0000; Pseudo R^2: 0.923; Log pseudolikelihood: 506.768 ***: significant at 1% level; **: significant at 5% level; *: significant at 10% level. Reference category: Severely food insecure

In the above econometric model, the dependent variable has four categories which are: food secure, mildly food insecure, moderately food insecure and severely food insecure as presented in Table 11. The model has a pseudo R^2 of 0.923 which means that 92.3% of the variation in the dependent variable is due to the variations in the independent variables.

The results of this first multinomial logistic regression model with initially estimated 11 independent variables assessed on the different categories of household food security status with severe food insecurity being a reference category, showed that 5 predictors out of 11 were statistically significant in influencing household food security status with probability of a household being in better off category compared to severe food insecurity. Age of the household head (AgHH), on farm income (ONFI), access to financial facility (AFF$_0$) have a significant P-value at 1% (P<0.01) while household livestock asset (LA$_0$) has a significant P-value at 10% (P<0.1), all of these 4 factors influence the probability of a household to be in the category of food secure compared to the category of severely food insecure. In the second category, factors like education (EDU, P<0.01); on farm income (OnFI, P<0.1) and livestock asset (LA$_0$, P<0.1) significantly influence the probability of a household to be in the category of mildly food insecure compared to the category of severely food insecure. None of the predictors were significant in influencing the moderately food insecure category in comparison to severely food insecure. In this first testing of the model with a combination of 11 predictors, independent variables like family size, farm size, gender, on farm house labor, access to trainings and extension services, as well as use of chemical fertilizers, did not have any significant influence on household food security status.

4.3.2.2. Adapted Model with Eight Independent Variables

Given that the first model did not show any significant predictor when comparing moderately food insecure category to severe food insecurity, more exercises of combining the independent variables in the model were performed to find out a more balanced spread of predictors across the three-better off food security status categories when compared to severe food insecurity. The final MLM adopted was the one combining: gender and education of household head; family size; farm size, on-farm house labor, on farm income, access to financial facilities and access to trainings and extension services. While age of household head was permitting the rise of R^2 up to 80- 90%, meaning that considered independent variables would affect the dependent variable at higher probability, very few predictors from the conceptual framework would make a significant influence. Thus, reducing to eight parameters showed more significant behavior. Tables 12; Table 13 and Table 14 show the final model fitting information, likelihood test and final parameter estimates.

Model Fitting Information (2)						
Model	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	666.563	678.368	660.563			
Final	585.752	715.603	519.752	140.811	30	.000

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	452.573	519	.984
Deviance	392.499	519	1.000

Table 12: Econometric Model Fitting

Effect	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	585.752	715.603	5.198E2[a]	.000	0	.
Onfarm income	660.683	778.729	600.683	80.931	3	.000
Family size	588.908	706.954	528.908	9.156	3	.027
Farm house labor	582.092	700.139	522.092	2.341	3	.505
Farm size	584.568	702.615	524.568	4.817	3	.186
Gender of HH	592.854	710.901	532.854	13.102	3	.004
Access to financial facilities	592.845	710.892	532.845	13.093	3	.004
Access to Agri trainings	584.743	702.790	524.743	4.991	3	.172
Education	573.038	667.475	525.038	5.286	9	.809

Table 13: Likelihood Ratio Tests

Food Security Status		Coeff.	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
Food Secure	Intercept	-26.643	3.344	63.463	1	.000			
	EDU	.399	.551	.525	1	.469	1.491	.506	4.393
	ONFI	4.753***	1.108	18.412	1	.000	1.907	13.222	1016.079
	FS	-.239	.473	.255	1	.614	.787	.311	1.991
	FMS	-2.176*	.870	6.262	1	.012	.113	.021	.624
	FHL	.471	.720	.427	1	.513	1.601	.390	6.568
	[GEN=.00]	.702	.741	.899	1	.343	2.018	.473	8.617
	[GEN=1.00]	0[b]	.	.	0	.	.	.	.
	[AFF=1.00]	-2.298***	.699	10.806	1	.001	.100	.026	.395
	[AFF=2.00]	0[b]	.	.	0	.	.	.	.
	[AGT=.00]	16.106	.000	.	1	.	9883148.178	9883148.178	9883148.178
	[AGT=1.00]	0[b]	.	.	0	.	.	.	.
Mildly Food Insecure	Intercept	-.910	1.071	.722	1	.396			
	EDU	-1.076***	.316	11.560	1	.001	.341	.183	.634
	ONFI	-.264	.256	1.065	1	.302	.768	.465	1.268
	FS	.481**	.240	4.016	1	.045	1.617	1.011	2.589
	FMS	.383	.311	1.519	1	.218	1.466	.798	2.695
	FHL	-.309	.342	.820	1	.365	.734	.376	1.434
	[GEN=.00]	.950***	.335	8.028	1	.005	2.586	1.340	4.988
	[GEN=1.00]	0[b]	.	.	0	.	.	.	.
	[AFF=1.00]	-.053	.379	.020	1	.889	.948	.451	1.995
	[AFF=2.00]	0[b]	.	.	0	.	.	.	.
	[AGT=.00]	-.595	.646	.850	1	.356	.551	.156	1.954
	[AGT=1.00]	0[b]	.	.	0	.	.	.	.
Moderately Food Insecure	Intercept	1.037	.801	1.675	1	.196			
	EDU	-.572***	.213	7.195	1	.007	.565	.372	.857
	ONFI	.015	.184	.007	1	.934	1.015	.708	1.456
	FS	.185	.180	1.055	1	.304	1.204	.845	1.714
	FMS	.039	.243	.025	1	.874	1.039	.645	1.675
	HFL	-.301	.262	1.323	1	.250	.740	.443	1.236
	[GEN=.00]	-.120	.287	.175	1	.676	.887	.505	1.557
	[GEN=1.00]	0[b]	.	.	0	.	.	.	.
	[AFF=1.00]	-.230	.281	.667	1	.414	.795	.458	1.379
	[AFF=2.00]	0[b]	.	.	0	.	.	.	.
	[AGT=.00]	-.839*	.453	3.438	1	.064	.432	.178	1.049
	[AGT=1.00]	0[b]	.	.	0	.	.	.	.

Table 14: Multinomial logistic regression Estimates

Number of observations: 378, Wald Chi^2 (24): 152.01; Prob=0.0000; Pseudo R^2: 0.370; Log pseudolikelihood: 506.768
***: significant at 1% level; **: significant at 5% level; *: significant at 10% level. Reference category: Severely food insecure

As presented in the above Table 11, this second model has a pseudo R^2 of 0.370 which means that only 37% of the variation in the dependent variable is due to the variations in the independent variables.

The results of this final MLM for the different categories of household food security show that on farm income (ONFI), family size (FMS) and not having access to financial facility (AFF) significantly (P<0.1) influence the probability of a household to be in the category of food secure compared to a household in the category of severely food insecure. Factors like education (EDU), farm size (FS) and gender (GEN) significantly (P<0.05) influence the probability of a household to be in the category of mildly food insecure compared to a household in the category of severely food insecure. Education (EDU) and agricultural training (AGT) significantly (P<0.01) and (P<0.1) influence the probability of a household to be in the category of moderately food insecure respectively compared to a household in the category of severely food insecure.

4.3.3. Statistically Significant Factors Influencing Household Food Security Status of Smallholder Farmers in Burera District
From the above multinomial logistic regression (Table 11), it can be observed that the hypothesized demographic and resource factors have an effect on the household food security status of the smallholder farmers in the following manner:

4.3.3.1. Resource factors
(a) On- farm income

The results from MLM show that on-farm increases the probability of a household to be in the category of food secure by 90.7 %(1.907-1) compared to being in the category of severe food insecurity.

Despite the low levels of observed on-farm income from the smallholder farmers of Burera District, the inferential statistic results of this study showed that at 1% level of significance, on farm income positively influences the probability of a household to be food secure by 90.7% compared to severely food insecure. A unit increase in on farm income will increase the probability of household to be food secure by 1.907. This means that the higher the household on farm income, the higher is the probability that the household would be food secure other things being constant. This is because on farm income will increase the purchasing power of a household and therefore enables a household head to access to available food from the market and increases the probability of that household to be food secure. On farm income will again help farmers to purchase inputs that will be used for the future planting season.

The results of this study are consistent with the study of Maksuda (2012) on the socio-economic factors influencing food security status of maize growing households in selected areas of Bogra district, Bangladesh. He found that monthly on farm income was positive and significant at 5% level. This is true because, most of farmers raised crops for two main purposes such as consumption and selling. On farm income depends on the quantity of the produce sold and its market price. In this context if a farmer gets income from his produce he can have access to other food commodity available to the market and therefore increase his/her level of food security. On farm income is the key factor that can be considered to increase the level of household food security, especially in the rural areas. Even though, on farm income is positive and significant, it can be noted that in order to help farmers to get profit from the farming business, at the time of harvesting, a cross check about the market structure (demand, supply and price) is advised because the farmers tend to sell at low prices during the harvest while in few days prices hike and the farmers can't afford to purchase food from market during the off-season. Another point to be emphasized on is that farming activities in Rwanda and in the mountainous Burera district in particular, are only seasonal and depends on rainy seasons. In the study area irrigation farming is almost nonexistent. Thus, the intensive farm activities time engaging men efforts is from sowing from tilling in August and sowing in September, the remaining works of crop thinning up to harvest in January are mostly done by women and children, living men idle for about 3 months, resuming again tilling and sowing in March and April, again having other 2-3 months idle. The particularity of   Burera district is that due to very high altitude, it is humid all year long in contrast of the most of other districts in country which only have two agriculture seasons and one 3-4 months dry period from end May to beginning / end September. This makes that in Burera district they can plant in 3 seasons, the season C of June –September being dedicated to planting Irish potatoes in the valleys and hillsides. Given that men tend to live many months of idle work, which makes them often wander around drinking bars and thus exhaust their limited income and end up suffering from the stress of food insecurity, it would be important to strategically identify potential off-farm employment which should keep them busy during the break periods from farming activities.

Similar observation was also noticed in the WFP's Comprehensive food security and vulnerability analysis (WFP, 2015) which stated that women are more often engaged in agricultural production and agricultural labor, while it is more common for men to work as unskilled laborers (non-agricultural), skilled laborers, salaried work or on their own business. This means that in rural areas where off-farm employment is scarce, there is a lost opportunity of engaging that idle labor, thus aggravating household food insecurity as they drain out even the little income of the household.

(b) Farm size

Farm size in this study referred to the land area that was actually used for crop production during the period of the survey. It is expected to influence positively household food security. The households who have larger size of farm are assumed to have more production which gives a better chance for the household to be food secure. The results of the present study show that, having an odds ratio 1.617 other thing remaining equal or after controlling other effects, farm size increased by 61.7 % the probability of a household to be classified as mildly food insecure compared to severely food insecurity at 5% level of significance. Thus, an additional hectare owned by a household increases the probability of a household being mildly food insecure by 61.7% compared to being severely food insecure. Large farm size allows households to practice soil conservation like crop rotation which enhances land productivity. This is in line with the findings of Ahmed Mohammed Abdulla (2015) who found that farm size had significant and positive effect with household food security status in Borana zone of Ethiopia. Thus, an increase in land size of 1 hectare would lead to the better food secure state of the household. Similarly, Omotesho et al. (2006) using a binary logistic regression model found that farm size affected positively household food security status. Despite this high level of probability associated with farm size, the fact that almost all the smallholder farmers surveyed operate on very small plots of land of less than a hectare as described above, efforts from the government and Non-Government Organizations should be multiplied to both increase small scale family agriculture production, but also to increase off-farm income generating and employment opportunities in the rural area of Burera district. This would allow the smallholder farmers to diversify the living livelihoods, thus cope with the pressing situation of food insecurity.

(c) Livestock asset

In the first ML Model run with 11 predictors initially hypothesized to influence food security status of the smallholder farmer's household, livestock showed to be significant at 10% in influencing the probability of a household to be in the category of food secure compared to the category of severe food insecurity. This is a normal expectation, given that livestock not only provides manure and thus better productivity of crops, but also it can be source of income to the household, usually maintained as "saving account" in the sense that it can be sold in the hardships to secure the family (Njarui et al, 2016). However, when the model was modified removing "age" factor, livestock asset did not have any significant influence in the subsequent predictors' combinations, thus removed from the final model.

On farm house labor did not show any significant influence in the model. This could be attributed to the fact that there is enough farm labor compared to the capital asset (available farm size), and this   spanned across all households independently of their food security status category. That is, there was no significant difference in distribution of on-farm house labor across the 4 categories of food security status.

4.3.3.2. Demographic Factors

(a) Family size

The current study found that high family size decreases the probability of a household to be food secure by 88.7 %(0.113-1) compared to severe food insecure insecurity. This is explained in the negative correlation that, as family size increases by one member, food security decreases. This is due to the fact that higher number of family tends to share the available food. Hence, increase in family size would lead to stretch the household food share. This confirms the Malthusian theory of population which emphasizes on the existing relationship between population growth and food production. Malthus stated that population trend follows a geometric progression while food production follows an arithmetic progression. Food production is one among the components of food security. Therefore, the growing number of population and family size are the challenges for the household food security. Taking into account these points, it is not a surprise to find the inverse relationship between food security and family size. This study is in agreement with the study of Adebayo (2012) who found family size to be negative and significant at 1% level. It showed an inverse relationship with household who are in the category of food secure. Similarly, Maksuda (2012) found a significant and negative relationship between family size and household with food secure compared to severely food insecure at 5% level and Patrick S. (2012) who reported that family size decreases the probability of a household to be food secure. Patrick (2012) explained that the family size and food security status inverse relationship indicates that increase in the member of household means more people are eating from the same resources, thus the household members may not be able to have enough food and therefore increasing the probability of the household to be food insecure.

(b) Gender of the household head

Gender is a relevant factor of food security among households. The current study found that household headed by females are more likely to be in the category of mildly food insecure compared to severely food insecure. Having an odds ratio of more than one i.e. 2.586, after controlling other regressors, households headed by female increase the probability of being in the category of mildly food insecure compared to severely food insecure and it is significant at 1% level. Similar results were found by Patrick S. (2012) who reported that households headed by females are more likely to be in the category of mildly food insecure compared to severely food insecure. The results of this study were against the findings of Mohammadi et al. (2011) who found that households headed by females were more likely to be severely food insecure compared to food secure and Fumane (2013) who found that gender of household had a negative and significant at 10% level meaning that a female headed household has a lower probability of being food secure as compared to severely food insecure. In the Rwandan context, mostly women are engaged in farming activities while men tend to move out of the family to look for off-farm employment, which in rural areas ends creating wandering behavior at the drinking bars rather than actually contributing to family income and thus to household food security.

Therefore, a household headed by a woman, having the full power of decisions making, will likely be more food secure compared to the those headed by males and inhibiting the decision making of their wives, instead draining out the little income available at home.

(c) Educational Level

In the normal expectation, Education could impact positively the household food security status. The higher the educational level of household head, the more food secure the household should be, with assumption that more educated household heads would easily and quickly adopt better farming techniques and better family resources management. The results from the present study revealed that Education level of household head negatively influenced the probability of household to be in the category of mildly food insecure by 65.9% compared to the category of severely food insecure. The results of the present study were against the findings of Tsegay G. (2009) who reported that educational level increases the probability of a household head to be in the category of severely food insecure in the Tefray region of Ethiopia and of Abdullah et al. (2017) found that education was positively influencing the household food security status. It indicated that the more the educated household head the more food secure the household, which was also initially expected for this study as well.

However, the negative sign of the coefficient in this study implies that increase in education by one additional level of schooling would reduce the probability to continue to work on farm, would there be off-farm opportunities, the household would acquire more income and be more food secure, but in absence of off-farm income generating opportunities, the farm labor would reduce due to idle workers and thus leading to food insecurity.

In contrary, the education level of all members of the household did not have any significant association with the food security status when run in the econometric model. This might be due to the fact that the only difference comes to the primary education of children which has increased, but still those are considered as dependents, not yet in the active age (less than 16 years old) to contribute to the farm labor. The introduction of free 12-year basic education policy in Rwanda is still new not more than 10 years of implementation, thus mass increase of primary level education for children has not yet reached its long-term impact on household food security. In future, when those children are grown and start seeking more on farm trainings and off-farm jobs, the positive effect of summed education level of household members on food security status could be detected.

(d) Age of the household head

In the first initial model with 11 predictors, age was found to negatively influence the probability of a household to be in the category of food secure by 93.2% (0.068-1) when compared to the category of severe food insecure. That means that any increase by one level range of age (from 18 years to 45; and from 46 to 65 and so on) will decrease the probability of being food secure by 93.2%. This is actually true, given that as the household head gets older, the physical energy to work on farm decreases and even chances of being employed in off-farm income generating activities decrease.

Age of the household head was however monopolizing the model, limiting the number of significant factors and their spread across all food security status. When age was removed, the model become more balanced. This phenomenon of aberrant behavior for age factor needs further investigations to understand it better. The findings in the first model were however in tandem with those of Bashir et al (2013) who found a negative relationship between the age of the household head and food security in Pakistan. Similarly, Godwin (2016) found that the probability of households being food secure or food insecure in rural areas of Benue was determined by age. Result from his study revealed that the coefficient of age was found to be negative and significant at 5 % which means that food security declines with increase in age of the household head. The negative and significant effects of age of the household heads decrease the probability of households to be food secure. Against these findings, Jemal and Kyung (2012) found that age of the household head was strongly and positively affecting food security in rural Ethiopia.

4.3.3.3. Institutional Factors

(a) Access to Financial Facility

The ability to get access to financial facility has a positive and significant impact on household food security. The results of this study in the connection of this regressor revealed that household heads with no access to financial facility decreases the probability of a household to be in the category of household food secure by 90% compared to the category of severely food insecure in the study area which was in complete agreement with the prior expectation. This might have been due to the fact that households with the opportunity to get financial facility (savings and loans) would build their farm production capacity through the purchase of agricultural inputs and cover other related agricultural costs that occurred in the process of crop production. The present findings are in line with the findings of Abdul (2015) which revealed that access to financial facility variable (dummy variable) was found to be negative and statistically significant at 1%. It implies that if a household head does not have access to financial facility; it will lead to a decrease in food security. Similarly, the findings of John et al. (2011) who reported that household that received financial facility all things being equal increased the probability of being in the category of food secure compared to those who were in the category of severely food insecure households. Also, Pilirani, et al. (2009) found a positive relationship between access to credit and food security which means that a household with better access to credit are more likely to be food secure This indicates that household that received financial facility had greater probability/chances/likelihood of being food secure compared to those who are in severely food insecure. Therefore, access to financial facility should be a vital area to be addressed in order to achieve household food security.

(b) Access to Agricultural Trainings and Extension Services

Agricultural training received by a household member as well as home visits of extension agents enhance the capacity to understand the various practices involve in crop production and easily apply them in the field. There is a trained farmer and non-trained farmer in the relation of the better food security. It is therefore hypothesized that a trained farmer has a positive influence on food security status than a non-trained household head. The results of the present study showed that the non-trained households decreased the probability of being in the category of moderately food insecure by 56.8% (0.432-1) compared to severely food insecurity. In another word, households who had not received any training were less likely to be in the category of moderately food insecure than being in the category of severely food insecure, which confirmed the expected sign and thus rejection of the null hypothesis. The finding was in line with Kipkurgat and Tuigong (2015) in their study on "Impact of agricultural Extension on Food Security among small scale farmers in Wareng District, Kenya" who stated that it may not always be possible to precisely quantify the contribution of extension services to food security, but agricultural

extension is important because in the first place, information about good or new agricultural practices is imparted to the end users.

(c) Government Policies

Although they were not analyzed in the model, it was also hypothesized in the conceptual framework that Government policies would also intervene in influencing or altering the effects of demographic and resource factors on household food security status. Some of the GoR policies relevant to mention include for instance the 9-year and 12 years free basic education which is rapidly changing the behavior of smallholder farmers who used to drop children from school for the sake of farm labor. Other policies include the land use consolidation policy and crop intensification program which among others subsidizes access to chemical fertilizers. Other policies and programs would include the "One Cow per Family program" (Girinka); the "Twigire Muhinzi" program under initiation (a new agricultural extension program by which Lead farmers are trained and contracted by districts to become extension service providers), etc. All these have in one way or another effect on the smallholder farming, though most of these are still new and their effects could only be detected in the years to come.

5. Summary, Conclusion and Recommendations
This last chapter aims to provide the summary of the study findings, conclusion as well as recommendations based on the study results.

5.1. Results Summary

5.1.1. Objective One: Socio-Economic Characteristics of the Respondent Smallholder Farmers
Out of the 378 smallholder farmers' households sampled, 66.1% had a family size of less than 5 members, while 33.9% had 5 and more family members. The mean of family size among respondents was 4.5 members. The dependence ratio was over one for 26.5% of respondents' households. Most of the sampled households (73%) were male headed; only 27% were headed by females. Regarding the marital status of the household head, it was found that 90.2% were couple, 1.9% adult single males and 7.9% adult single females. It was also found that 52.9% of sampled household heads had never attended school, while 43.1% had only been in primary school. Only 3.9% had been at the level of high school. Looking at all the household members' education level, 67.5% of the sampled households had at least one family member who attended primary school level and only 6.6% had a member who ever reached high school level of education. About the age of the household head, the study found that 57.7% of smallholders' household heads were aged between 18years and 45, while 30.2% had age between 46 and 65 years. Only 12.7% were aged beyond 65 years. The mean age of the household heads was found to be 44.8 years. The results showed that the majority of the smallholder farmers in Burera district operate on small plots of land, with 77.7% of the respondents having less than 1ha of land, 50.5% owning between 0.5 and 1 ha, while 27.2 % lived on less than 0.5 ha of land. About 54.2% of the sampled smallholder farmers owned at least one livestock (either cow, goat, sheep or pig) with only 15.87% having cows in their households. For the average annual income from the farming activities, 41.3% of respondents earn less than 200.000 FRW (less than 250 USD with exchange rate of 800FRW/1US$), 42.9% earn between 200.000 and 300.000 FRW (250-400 USD), while only 15.9% could earn above 300.000 FRW (400 USD). Regarding the availability of labor resource factor, 31.2 % of the sampled households had only one member in active age who could be relied on to supply labor, 45.8% had 2 active members while 23% had more than 2 active members catering for the household. Only 8% of the respondents had received agricultural training or extension assistance within the one-year period from the date of interview. Financial literacy among the smallholder farmers and access to financial facilities are also very limited, only 28% of the respondent had some mechanisms of saving and accessing to loans, among them 20% were using informal savings and lending groups of neighbors (IBIMINA), while only 8% were using the formal Saving and Credit Cooperative (SACCO) available at sector level. None of the respondents had ever acquired loan from any bank. Only 25% respondents had used mineral fertilizers at least in the previous 2 agricultural seasons preceding the time of interview.

5.1.2. Objective2: Household Food Security Status among the Respondent Smallholder Farmers
The results showed that out of 378 smallholder farmers 'households interviewed, only 24 households representing 6.3% were found to be in the category of food secure representing, 59 were mildly food insecure (15.6%), while 131 were moderately food insecure (34.7%) and 164 were severely food insecure (43.4%). The results showed that there is a big proportion of smallholder farmers living in a situation of food insecurity, with only 6.3% of the sample not being worried about food availability and access.

About the stated anxiety and uncertainty about food, as well as household experience with the quality of food (limited varieties and unmet preferences) and the experience with insufficient food intake (quantity of food consumed), 58% of the respondent smallholder farmers had been worried for some time or so often about access to enough food. 45% felt they had eaten so often the kinds of food they did not prefer because of lack of resources; 60% experienced so often a situation of eating few kinds of food (limited varieties) while even 62% confirmed that it happened so often to eat kinds of food that they should not eat but due to limited means they had to. Very few (10%) expressed that it has sometimes happened to miss food at all in their households, though still 28% experienced a situation of sometimes going to sleep feeling hungry because there was not

enough food. Though it might be exaggerated, 5% expressed that it rarely happened to go a whole day and night without eating anything.

5.1.3. Objectives3 &4: Effect of Resource and Demographic Factors on Food Security Status

To achieve the objectives 3 and 4, based on the factor analysis of the HFIAS, the multinomial logit model was applied by regressing the eleven predictors such as gender, education and age of the household head, on farm Income, Farm size, Family size, farm house labor, access to financial facility and access to agricultural trainings and extension services. Before regressing, the diagnosis of the multicollinearity was prior analyzed through the application of correlation matrix, Variance Inflation Factor (VIF) and tolerance statistics. The results showed that there was no multicollinearity among the set variables. Due to its higher proportion in the model, severely food insecure category was set as a reference category. The inferential analysis of the first multinomial logit model with 11 predictors revealed that Age of the household head, on farm income, access to financial facility significantly (P<0.01) and household livestock asset (LA_0) significantly (P<0.1) influenced the probability of a household to be in the category of food secure compared to the category of severely food insecure. Factors like education significantly (P<0.01) influences the probability of a household to be in the category of mildly of food insecure compared to the category of severely food insecure while on farm income and livestock asset significantly (P<0.1) influenced the probability of a household to be in the category of mildly food insecure compared to a household in the category of severely food insecure. None of the predictors were significant in modelisation of the moderately food insecure in comparison to severely food insecure.

Given that the first model did not show any significant predictor when comparing moderately food insecure category to severe food insecurity, more exercises of combining the independent variables in the model were performed to find out a more balanced spread of predictors across the three better food security status categories when compared to severe food insecurity. The final MLM adopted comprised 8 predictors: gender and education of household head; family size; farm size, on-farm house labor, on farm income, access to financial facilities and access to trainings and extension services. The results of this final MLM showed that on farm income, family size and access to financial facility significantly (P<0.1) influence the probability of a household to be in the category of food secure compared to a household in the category of severely food insecure. Factors like education, farm size and gender significantly (P<0.05) influence the probability of a household to be in the category of mildly food insecure compared to a household in the category of severely food insecure. Education (P<0.01) and agricultural training (P<0.1)   significantly and influence the probability of a household to be in the category of moderately food insecure compared to a household in the category of severely food insecure.

5.2. Study Conclusions

In many parts of the world and particularly in Rwanda small holder farmers are struggling to maintain food self-sufficiency mainly due to the decline of land per capita, most of them are poor and cannot afford to buy agricultural inputs. Traditional agricultural practices and farming on very small plots of land   lead to very low agricultural production, keeping most of the smallholder farmers at subsistence level, contributing little income to their livelihoods. An understanding of the socio-economic determinants of households' food security among smallholder mixed farmers would contribute and allow appropriate policy formulation that help smallholder farmers to change the status of their food security level. The study aimed to explore the socio-economic determinants of food security among the smallholder mixed farmers in Burera district of Rwanda. Based on the findings of this study per each specific objective, it is concluded as follows:

5.2.1. Resource and Demographic Profile of Smallholder Farmers in Burera District

The smallholder farmers of Burera district operate on very small pieces of land, the majority having between 0.5 and 1hectare for food production and generating very low income from farming activities. Although at the first instance we could conclude that absolutely a household cannot persist on such small piece of land, thus making it the first predictor of their severe food insecurity situation, experiences from other countries like Bangladesh showed us that a small piece of land of the size like 0.24 ha can be highly productive to generate 1.4 USD per day per capita. Therefore, the small size of farm does not necessarily lead to food insecurity if other production factors are optimized -efficient use of inputs and knowledge factor- (Rapsomanikis, 2015).

The study also found that there is enough farm labor at household level among the smallholder farmers, which might be even more than required when comparing the labor per capital ratio. The majority of the smallholder farmers 'households have 2 and more members working on daily basis on a piece of land less than 1 hector. Thus, on farm labor constitutes extra resource invested in the smallholder farming, in contrast of rational profit maximization, although it might not be called irrational behavior, rather lack of alternate options. The extra- labor among the smallholder farmers of Burera is also linked to the large family size thought the study found the average to be slightly lower compared to the national average family size, and there has been decrease of family size in Burera district over the last 7 years, comparing EICV3 (NISR, 2011); EICV4 (NISR, 2015) and the findings of the current study. Extra-labor not fully exploited could lead to idle manpower, consuming without producing it is unavoidable to be fed on daily basis at household level without their contribution to the household food and income.

Livestock asset ownership is still very low, while it is the main source of organic manure. Access to and use of chemical fertilizers is still very low, which might be linked to the very limited access to agricultural extension services, although income factor also plays in as they have to pay 50% of the price, the remaining 50% being subsidized by the Government. Low use of fertilizers could be also linked to limited access to financial facilities, where not only they should be adopting the culture of saving for inputs, but also have the facility to acquire inputs loans.

Education level among the Smallholder farmers of Burera district is still very low, which might impact on adoption of improved farming techniques and business oriented farming. Positive effect of literacy could be also expected in more demand for financial services and creation of off-farm employment to complement on farm income.

5.2.2. Food Security Status

The majority of smallholder farmers in Burera district have shown to be severely food insecure (43%) meaning that they are chronically food insecure all year long. Moderate (34.7%) and mild (15.6%) make up 50.3% of the households that could be considered as marginally food secure, that is, facing transitional periods of food insecurity over the year, but can easily shift to food security category. A very low proportion of smallholder farmers (6.3%) was found to be food secure. Due to different measurement methods and classification terminologies, the current study could not confirm the recent WFP national food security categorization from the 2015 Rwanda comprehensive food security and vulnerability analysis (WFP, 2015). WFP had stated that based on food security index, there are 40%food secure households in Rwanda, 40.2 % marginally food secure, 16.8% moderately food and only 2.6% severe food insecure households. The differences in the two measurement tools (Food security Index and HFIAS) and terminologies should be investigated further as both are internationally validated, in order to come up with a customized food security measurement tool for Rwanda.

5.3.3. Socio-Economic Determinants of Food Security

On-farm income and farm size were found to be resource factors that consistently affect the household food security status among the smallholder farmers. Family size, gender and education of the household head were also the demographic factors that significantly affected the food security status.

Institutional factors such as access to financial services and access trainings to extension services also significantly influence the food security status.

The fact that family size was found to negatively affecting the food security status also confirmed the Malthusian theory of population growth. Both Food availability decline and food entitlement theories were also confirmed by the limited resource factors as farm size, on farm income and limited access to institutional services which showed to be significantly affecting the food security status at household level.

5.4. Recommendations

5.4.1. Recommendations for GoR and Development Partners

Based on the findings of this study, Government policy makers and development partners should take immediate actions to address the serious issue of food insecurity among the smallholder farmers.

(a) **Improving the productivity on small-sized farms**: this could be done through optimizing use of other farming inputs such as improved seeds, use fertilizers (both manure and chemical) and overall improved farming practices. While the public extension services are still very limited and constrained in number, time and resources, the development partners (both international and local NGOs) should take this issue as emergency case, to ensure there is a boost of productivity per area.

(b) **Restructure and reorganize agricultural extension service delivery:** The current public extension system based on one agronomist and one veterinary at sector level has proven inefficient. Efforts should be multiplied, either to have at least an agronomist at cell level equipped with transport means, or more capacity building and steady business plan should be developed for the newly designed "Lead farmer" model, which stipulates that lead farmers will be selected from each 15 neighboring households, trained as extension facilitator and then form a professional cooperative which would be contracting with districts to provide home to home extension services.

(c) **Improve the value chains of rapid growing and high value crops:** It has been widely documented that small pieces of land, to be optimal, should be planted with rapid growing crops which are harvested in the very short periods, thus generating quick revenues to the smallholder, but also allowing the smallholder to cope with the long seasons in between two harvests of staple crops. Thus, value chains of horticultural crops (vegetables and on farm fruit trees) should be emphasized. The value chains should be complete enough to identify market niches in order to resolve the current issues where there is surplus production at local markets at the times of harvests and farmers are obliged to sell at very low prices that do not cover production costs, while in towns and secondary cities, prices double or triple.

(d) **Multiply off-farm employment opportunities in rural areas:**   based on the findings that income from farming activities are very low, but which could increase if optimal use of the production factors is considered, many adult members of the smallholder farmers' households might abandon farming. This was demonstrated by the negative effect of education level on the household food security status of smallholder farmers, meaning that as the education

level tends to increase a general tendency would be to abandon farming, while there is no alternative employment, thus creating idle skilled and non-skilled workers who spend their days at the local business centers and at the end of the day consume from the household without an added income to the household. Also, the fact that the country is currently implementing the 12-year basic education policy should be factored in with the risk of increasing idle manpower while farming would not be attractive to them anymore. Therefore, alternative measures that improve cash earning opportunities through the adoption of cash crop cultivation, should go hand in hand with creation of off-farm enterprises in the study area as key factor of household food security.

(e) **Increase awareness and sensitization on family planning.** All concerned persons, from the local administration in the study area, NGOs and central government level should take stock of the progress in family planning which reduced the average family size by 2 scale points (from 4.8 to 4.6) over a period of 4 years between EICV3 of 2010/2011 and EICV4 of 2013/2014. The fact that this study proved the negative relationship between family size and food security status should call for more enhanced awareness raising among the smallholder farmers.

(f) **More efforts in rural women empowerment:** This study proved that women –headed households have higher probabilities of becoming food secure. Thus, this should encourage for more sensitization of men and women in the study area and across Rwanda, so that men let their wives to take up responsibilities of managing the household. It is not easy due to cultural beliefs and behaviors, but the comparative advantages should be weighted.

(g) **More sensitization and availing financial services.** The study proved that not accessing financial services negatively affected the household food security status. Thus, more sensitization and promotion of financial literacy among the smallholder farmers should go hand in hand with efforts to avail more banks and non-bank financial services, ensuring that smallholder farmers have opportunity to save for money for inputs purchase, but also to be able to acquire small loans to smoothly invest and run agricultural season. Therefore, efforts to make adapted loans conditions and saving incentives should be created.

5.4.2. Recommendations for Future Researches

(a) Facilitate more research on small scale farming and food security at micro-level

So far, the only available studies in Rwanda related to food security are those carried by WFP at macro-level. However, it is very imperative to further investigate and measure the production factors among the smallholder farmers. There is literature gap on productivity of small scale farms and their contributions to the national food security and economy. The government should facilitate research and development in food security and support it with necessary funding. Micro-level studies should be given a similar emphasis as Macro level studies in order to ensure smallholder farming and household food security are continuously assessed in all the districts of Rwanda.

(b) Need to test and adapt an appropriate household food security measurement tool:

There are several measurement instruments of food security, at macro and micro level, however many of these instruments need cultural adaptation and contextualization in order to make sense. In order to reach a common ground of food security classification in Rwanda, research academies should initiate more researches on food security at micro and micro-level, testing and adapting different tools to come up with an adapted tool and classification of food security status in Rwanda.

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Appendix 1: Household Food Insecurity Access Scale Score (HFIAS) as a measurement of food access
The HFIAS is a nine-question tool developed and validated by the Food and Nutrition Technical Assistance (FANTA) to assess household food insecurity, and looks at three key domains experienced in households during the previous month:
1. Stated anxiety & uncertainty about food
2. Household experience with quality of food (variety & preferences)
3. Insufficient household food intake (quantity)

The 9 questions are as follow, referring to the past 30 days:
Q1-Did you worry that your household would not have enough food?
Q2-Were you or any household member not able to eat the kinds of food you preferred because of lack of resources?
Q3-Did you or any household member eats just a few kinds of food day after day due to lack of resources?
Q4-Did you or any household member eat food that you preferred not to eat because of lack of resources to obtain other types of food?
Q5-Did you or any household member eat a smaller meal than you felt you needed because there was not enough food?
Q6- Did you or any household member eat fewer meals in a day because there was not enough food?
Q7- Was there ever no food at all in your household because there were not enough resources to get more?
Q8-Did you or any household member go to sleep at night hungry because there was not enough food?
Q9-Did you or any household member go a whole day without eating anything because there was not enough food?

Each question's score depends on how frequent the household has lived with that situation in the past 30 days: never happened= 0, rarely (once or twice) = 1, sometimes (3-10 times) = 2, or often (more than 10 times) = 3. A total score for the household ranges on a scale from 0 to 27.A higher HFIAS score is indicative of poorer access to food and greater household food insecurity.
Prevalence of food insecurity is further categorized as follows:
1. Food secure: if[(Q1=0 or Q1=1) and all other questions =0
2. Mildly food insecure: if [(Q1=2 or Q1=3 or Q2=1 or Q2=2 or Q2=3 or Q3=1 or Q4=1) and Q5, Q6, Q7, Q8, Q9=0]
3. Moderately food insecure: if [(Q3=2 or Q3=3 or Q4a=2, Q4=3 or Q5=1 or Q5=2 or Q6=1 or Q6=2) and Q7=0 and Q8=0 and Q9=0]
4. Severely Food Insecure if [Q5=3 or Q6=3 or Q7=1 or Q7=2 or Q7=3 or Q8=1 or Q8=2 or Q8=3 or Q9=1 or Q9=2 or Q9=3]