MARKET PARTICIPATION AND ITS EFFECT ON EMPLOYMENT AND FOOD ACCESS WITHIN HOUSEHOLDS OF SMALLHOLDER WOMEN FARMERS IN RWANDA

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DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this thesis is my original work and has not been submitted for a degree in any other University or any other award.

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DEDICATION

I dedicate this work to the memory of my late mother, forever missed for her love, diligence, wisdom, and generosity. I also dedicate this to my father, for his unwavering encouragement and trust that have established the basis of this achievement.

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ABSTRACT

Agricultural transformation is key to poverty reduction and food security in Sub-Saharan Africa (SSA). In Rwanda, transformation efforts have been focused on increasing smallholder farmers' participation in agricultural markets, with a purpose to shift them from subsistence to market-oriented production. In spite of this, subsistence farming is still dominant, involving more women than men and little is known on the progress of these farmers towards market orientation. This study contributes to the existing knowledge by examining how smallholder households and women in particular, integrate in the current marketing system while determining the drivers of output market participation as well as its effect on food access and on-farm employment. The study's contributions is three-fold. First, it provides empirical evidence on the relationship between the output market participation and food access and on-farm employment. Second, the study highlights gender issues as well as women's social and economic conditions that require attention to increase smallholder households' participation to output market. Finally, the design of this study allowed to provide some knowledge on two under-researched topics; on-farm employment and experience of women as individual farmers in the on-going agricultural transformation. It used a mixed method approach with a quantitative survey on respectively 211 and 178 beans and potato producing households, 7 focus group discussions and 10 key informant interviews, under a sequential explanatory design. Double Hurdle model, Logit models and inverse probability weighting estimator with regression adjustment (IPWRA) as well as the qualitative thematic analysis were used. Results showed that 56% of the total sample has participated in output markets while 34.7% were market oriented. Based on the Household Commercialisation Index (HCI), the average participation was higher among potato producing households (80% versus 34% for beans). Landholding and income, proximity to all-weather roads, women's education, group membership, possession of mobile phone and women participation in decisions on quantity sold determined the households' market participation. Women's low participation in the marketing system, limited control over agricultural income and increased workload were the primal hindrances to households' market participation. Households with high degree of market participation had higher likelihood to be in better category of food access and food secure. Women's participation in decisions on quantity to sell, education and saving have positively influenced food access. Households that participated to output market, generated 19% more on-farm employment than they would have generated without market participation in output market. The study recommends women's participation in groups, training and use mobile phones to access information and improve their bargaining ability in households' decisions. Campaigns on gender equality target smallholder households. Improvement of rural all-weather roads, households' income, and linkages in the marketing system was also recommended.

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LIST OF ABBREVIATIONS

AfDB	African Development Bank
AU	African Union
CAADP	Comprehensive Africa Agriculture Development Program
CIAT	International Center for Tropical Agriculture
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GoR	Government of Rwanda
ILO	International Labour Organisation
MDG	Millennium Development Goal
MINAGRI	Ministry of Agriculture and Animal resources
MINECOFIN	Ministry of Finance and Economic Planning
NISR	National Institute of Statistics of Rwanda
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental organisation
RAB	Rwanda Agriculture and Animal Resources Development Board
RDB	Rwanda Development Board
WFP	World Food Program

CHAPTER ONE
INTRODUCTION

1.1. Background information

In Africa, efforts for agricultural transformation are intended to reduce poverty and hunger among the majority of the population whose economic activity is agriculture-based. As a shift from less productive subsistence to market-oriented agriculture, agricultural transformation is expected to be a trigger of long-run economic growth and individual well-being (Self & Grabowski, 2007). This growth particularly applies to the landlocked resource-limited countries of the Sub-Saharan Africa (SSA), where economic growth and poverty reduction need a strong focus on agricultural performance (Dercon, 2009; Collier & Dercon, 2014). Hence, the interest to agricultural transformation that has revived since the 2000s, leading to continental initiatives such as the Comprehensive Africa Agriculture Development Program (CAADP) (Wiggins, 2014).

In CAADP, African countries renewed their commitment to develop the agricultural sector while focusing on smallholder farmers and women in particular (NEPAD, 2018). The particular attention to these categories of farmers is in line with the Sustainable Development Goals (SDGs) of achieving gender equality and promoting inclusive, sustainable economic growth and productive employment for all (AU & NEPAD, 2014; Chandiramani, 2014). The CAADP is based on four pillars namely the expansion of land under sustainable management and water control systems, the improvement of rural infrastructure and trade capacities for market access, the increase of food supply and food security, the improvement of agricultural research, technology transfer and adoption.

Rwanda as a member of the AU, signed the CAADP agreement in 2007 and this reinforced the country's commitment to develop the agricultural sector. The sector received particular attention due to its place in the economy of the country. Actually, agriculture is still considered as a key element of the economy and livelihoods in Rwanda, though other sectors like industry and services are also growing. It contributes more than 52% of Rwanda's export revenue and up to 31% of the GDP (MINAGRI, 2018b; WFP, 2018; MINECOFIN, 2014). Moreover, the sector plays a big role in food security as the local production covers about 90% of the consumed food in the country (RDB, 2012). Hence even before CAADP, the country had a plan for agricultural transformation guided by its development strategy; the Vision 2020.

The need for agricultural transformation in Rwanda is accentuated by the country's high population density and agricultural land scarcity, limited natural resources, geographical location as well as its historical context. Already back in the 1990s, Von Braun *et al*. (1991) analysed the development of agriculture in Rwanda and highlighted the potential of agricultural transformation for income, employment and food security among the then growing number of poor smallholders. They recommended an urgent acceleration of development and dissemination of agricultural innovation as well as development of market infrastructure. The follow up on this, was disrupted by the genocide of Tutsi that worsened the situation of farmers and women in particular, by destroying the human, socio-economic structure of the country (Hitayezu, Okello & Obel-Gor, 2014).

The arable land size has also been reducing over the years at the level that most of the farmers produce on less than one hectare per household and only 6% of the farmers have more than two hectares (Ali *et al*., 2014). Agricultural production has remained largely for household subsistence and have poorly performed, though the sector has been always targeted as the major element of economic growth. Thus in the Vision 2020, Rwanda acknowledged that the major causes of this poor performance were low productivity related to subsistence farming (GoR, 2000).

The country emphasised on the transformation from subsistence to market-oriented agriculture (Verhofstadt & Maertens, 2014; Ministry of Agriculture and Animal Resources [MINAGRI], 2010). This was first envisioned as a pathway to increased agricultural productivity and production for enhanced food security and poverty reduction through more agricultural income among smallholder households (Barrett, 2008;GoR, 2012). Second, the promoting market oriented agriculture was not only intended to create more agricultural jobs but also to have spill-over effect into other sectors, leading to more non-farm employments (GoR, 2000; MINAGRI, 2013). All interventions are to be gender mainstreamed, recognising women farmers as the backbone of agricultural commodity chains in which, 75% of rural women against 65% of men contribute (MINAGRI,2010; NISR & MINECOFIN, 2014). This vision of transformation in Rwanda match up with that of CAADP through which countries were recommended to ensure gender equality in agricultural markets and market-led growth as they pursue higher productivity. In this vein, the country established the Crop Intensification Program (CIP), a cornerstone program in the process of the so-called transformation (MINAGRI, 2017).

1.1.1. Bean and potato among the priority crops in Rwanda

Through the CIP, efforts to agricultural transformation were initially focused to 6 priority crops namely maize, wheat, rice, beans, potato, cassava (NISR, 2019). The activities of CIP are mainly oriented at facilitating the transformation process through accessible and affordable improved inputs, training of extension officers, organised markets and dissemination of market information for the target crops (MINAGRI, 2017; NISR, 2019). Since the establishment of CIP in 2007, the use of improved inputs has increased followed by a higher market participation. For example in a comparison made by MINECOFIN (2013), the use of fertilisers has tripled in the period between 2006 and 2011, output market participation has increased from 21.5% to 26.9% of marketed outputs in farming households. Moreover, the yield of the priority crops increased remarkably in this period, to become stable for most of the crops except bean.

According to MINAGRI (2018), bean and potato were the two crops that had yield increment in the period between 2013 and 2016. Compared to other initial priority crops, both crops tend to be gendered. Bean though grown by up to 93% of farmers, is generally known as a woman crop while potato is a man crop or gender-neutral, depending on regions (Giertz *et al*., 2015). Figures from the recent national agricultural survey show that from 2018 to 2019, the total production of these crops have also increased, shifting from 835,576 MT to 896,747MT for potato and 484,729MT to 489,724MT for bean (NISR, 2018, 2019). In these two cropping years potato yield increased from 8.6 T/ Ha to 10 T/Ha while bean crop remained at 0.9 T/Ha (NISR, 2019). In terms of consumption, bean is highly consumed in Rwanda making it a potential cash crop with the rising population and food demand in the country. Actually, Rwanda has the highest level of per capita bean consumption in the world with 164 g per day and an average consumption of 6 days per week in the rural area (Mulambu *et al*., 2017). Bean crop being a woman crop would therefore be a good instrument for income generation among smallholder women farmers. In terms of market participation, Giertz *et al*.(2015) , citing figures by the World Food Program(WFP) showed that potato was grown by only 15% of farming households but the proportion of output sold outstrips that of other staple crops including maize, cassava and beans. Thus, a part from being a well performing crops in terms of productivity, the increasing commercialisation of potato make it an interesting crop for research on market participation. Moreover in the plan for transformation (2013-2016), the country had an ambitious plan of increasing the national potato yield by 50% which called for informed strategies (MINAGRI, 2009).

1.2. Statement of the problem

Agricultural transformation strategies target to increase smallholders' market participation which is considered as a key step towards market oriented production. Rwanda considers this transformation as a pathway to food security and poverty reduction through income from output commercialisation and employment. The country also recognises the importance of women and has been keen to mainstream gender in all interventions in the sector. Actually, the country is internationally acknowledged for its efforts in promoting gender equality in all sectors. However, despite some remarkable results in terms of agricultural productivity and commercialisation, more women than men have remained in subsistence production system. Unexpectedly, their number in subsistence production has even increased in the last decade (MINECOFIN, 2013). Moreover, there is a view that promoting market oriented production and output market participation could rather leads to higher risks of food insecurity within smallholder households as well as unemployment for the unskilled on-farm workers, who may be replaced by machines as farmers develop (Ansoms & Rostagno, 2012).

So far, neither the state of output market participation among the smallholders nor its impact on food security or rural employment has been empirically analysed. Additionally, despite the gender sensitive environment, there is limited knowledge on how women get integrated in the process towards the envisioned market-oriented production. Yet, women are considered to be more engaged in agriculture. An understanding of their participation to output markets as well as the limitations they face in the current marketing systems would inform on how to reduce the number of famers in subsistence production. This study endeavoured to determine the drivers of output market participation and its contribution on food security and on-farm employment within smallholder households. Moreover, the study focused on women in order to generate more knowledge on their degree of participation in output market and marketing system in general. This also helped to identify the limitations that may be keeping them in subsistence farming and the entry points to increase their households' participation to output market. Taking the Northern Province as a case study, the study used bean and potato as two of the Rwanda's priority crops with good progress in terms of productivity and output commercialisation.

1.3. Objectives

General objective

To contribute to improved livelihoods in the rural households of the Northern Province of Rwanda through increased participation in bean and potato output market among smallholder women farmers.

Specific objectives

- **i.** To examine the level of smallholder households and women farmers' participation in bean and potato marketing system as they progress towards market oriented production.
- **ii.** To determine the household and women's characteristics that affect smallholder households' participation in bean and potato output market.
- **iii.** To determine the influence of output market participation on food access among beans and potato farming households.
- **iv.** To evaluate the effect of output market participation on farm employment among bean and potato farming households.

1.4. Research questions

This study answered the following research questions:

- **i.** What is the level of smallholder households and women farmers' participation in the bean and potato marketing system as they progress towards market oriented production?
- **ii.** Which household and women characteristics affect smallholder households' participation in bean and potato output market?
- **iii.** What is the influence of market participation on food access among smallholder households?
- **iv.** What is the effect of output market participation on farm employment among smallholder households?

1.5. Justification of the study

After more than a decade of efforts to agricultural transformation, there is a need for more informed actions to achieve inclusive market orientation in Rwanda. It is also important to know whether the increasing participation to output markets, brings the desired outcomes on food security and poverty among the smallholder households. The number of scientific works on agricultural transformation and smallholder households in Rwanda is generally limited. However even among those available, market participation and its effects have not yet been directly

researched. Some studies were done on the components of agricultural transformation such as credits, farmers' cooperative and access to agricultural innovations while others analysed the transformation process using secondary data (Ansoms & Rostagno, 2012b; Hitayezu *et al*., 2014; Van Damme, Ansoms, & Baret, 2014; Ellen Verhofstadt & Maertens, 2014).

This study complements the available knowledge in Rwanda by showing, the empirical connection between output market participation, rural employment and food security. Being one of the few studies on informal rural employment in the SSA (Oya, 2013), it sheds light on how output market participation influences the creation of on-farm employment. The study also used bean and potato as two of priority crops in the country that have social constructs of being women's or men's crop. The choice of the crops allow more focused findings that helps to understand how women integrate in the current marketing system as well as the challenges they face in the transformation process. With a particularity of focusing on women as individual farmers, the study brings out the linkage between women farmers' characteristics and their households' participation in output markets. The results from this study come as a contribution to the achievement of gender equality in the process of agricultural transformation.

The findings from this study will be shared through policy briefs and direct discussion in workshops to inform policy makers and some findings have been shared with various stakeholders including NGOs, the local government authorities and the private sector for conscious interventions. Finally, the study contributes to the scientific knowledge by showing the position of women in households' and the implications of smallholder market participation on livelihoods and well-being in rural areas. Out of the findings from this study, two papers have been published and areas for further research in Rwanda and beyond were identified. Communications to smallholder farmers have been also started and based on the results of this study, a project to increase women's capacity and benefit from the on-going agricultural transformation has been initiated.

1.6. Scope and limitations of the study

This study covered the districts of Burera, Musanze and Gakenke in the Northern Province of Rwanda. It focused on women farmers from smallholder households who were either the head or the spouse of the household head and who mainly work as self-employed in their household farms. In this study, the market participation analysis only considered producers, the other actors in the marketing systems were not considered in detail. In the analysis, the study considered two of most the national priority crops which had been grown in the year 2015. These are bean and potato. The

major limitation of the study is that its analysis of household food access is based on only 4 weeks period of October 2015. With longer period and in different months, the results may be different.

1.7. Definition of terms

Agricultural commercialisation: The term is used to describe the situation by which a farm household shifts from subsistence to market-oriented production system with an objective to maximise profit. In this case, commercialisation also influence on both the input demand and output supply in these households (Abdullah *et al*., 2019). By this definition, commercialisation and market orientation are considered to be of the same meaning.

Agricultural transformation: This consists in shifting from the largely subsistence to market-oriented agriculture (GoR, 2000). At farm level, the transformation is accompanied by an increased agricultural intensification and commercialisation.

Dual-headed household: This refers to a household in which both a husband and wife leave together. As defined by Flato *et al* (2017), they are those households that have both an adult man and a woman who are at the top of decision making in a household. In context of Rwanda, spouses in registered marriage have legal equal rights to household's properties including land (Bayisenge, 2018).

Feminisation of agriculture: The term feminisation originates in poverty debates in which the feminisation of poverty is used to illustrate the fact that more women live in and suffer extreme poverty than men (Bieri, 2014). The feminisation of agriculture describes the increasing share of women's participation in agricultural labor compared to that of men (Jiggins, 1998; De Schutter, 2013).

Feminisation of responsibility and obligation: The term is proposed by Chant (2014) when explaining the feminization of poverty. According to Chant (2014), feminization of responsibility refers to the situation by which women increase their contribution to the survival of households, becoming more responsible of poverty reduction by increasing their growing participation in remunerated activities. Despite their growing participation in paid activities, women retain their primary responsibility for household unpaid work while men are not significantly in the household work and even tend to reduce their economic contribution (Chant, 2006). Therefore, women progressively have less choice other than to remain at the frontline of poverty management, investing greater labour in paid works but also supplying unpaid labour within households to compensate for men's contribution (Brickell & Chant, 2010; Chant, 2014)

Food access : Food access is one of the four dimensions of food security (FAO, 2012). It is defined as the ability of consumers to access adequate resources for acquiring sufficient and appropriate food (FAO, 2006; Anderman *et al*., 2014) and it is determined by households' access to resources and livelihoods coping strategies (Barrett, 2010; FAO, 2012).

Gender division of labour: This conveys the roles and activities that are socially defined and considered to be appropriate for women and men (Reeves & Baden, 2000).

Gender relation: Hierarchical relation of power between women and men that tend to disadvantage women (Agarwal, 1997; Reeves & Baden, 2000). The gender relation is also socially constructed and it influences how women and men access and control resources within households.

Household: This refers to a group of people that live in the same housing unit and share their food together. They may have different economic activities or participate in the same productive activity (Beaman & Dillon, 2019). However, in either case, they have all have a concern of the well-being of each other though may be having different preferences (Mattila-Wiro, 1999).

Market oriented farming : A household is said to be market oriented when the agricultural production is predestined to be sold, based on market signals (Gebremedhin & Jaleta, 2010; Kahan, 2013).

Market participation: This refers to when a household sells its agricultural production even when this was not *a priori* planned. Market participation is considered as a key step in the transformation from subsistence to market oriented farming (Biénabe & Vermeulen, 2011; Okezie *et al*., 2012). It can also be seen as an indicator of market orientation as research showed that market orientation strongly translates into market participation (Gebremedhin & Jaleta, 2010). In this study, the level of market participation is used as an indicator of the progress towards a transformed, market oriented farming among smallholder households.

Marketing system: This refers to a network of individual, households, firms and/or entities that are linked directly or indirectly in creating or making available a particular product in response to the market demand (Layton, 2007; Shaw, 2014).

Productive work: This relates to economic activities including paid or own-account works. Farming is considered as a productive work though unpaid for women in most of cases (Kabeer, 2016).

Reproductive work: This comprises all the activities performed within households including care giving and domestic works such as child care, cleaning and cooking. Most of these activities are

unpaid and they are universally under the responsibility of women, given the traditional gender division of labour (Pearson, 2000).

Rural employment: Based on the definition by FAO (2012); this refers to any activity or occupation that is done by rural people, for remuneration, profit, family gain, in cash or in kind, including both agricultural and non-agricultural activities. This study is focusing on on-farm paid employment.

Smallholder farmer: Farmers can be categorised based on criteria such as the use of bought inputs, market orientation, their level of access to technologies or their level of vulnerability to risks but also based on their land holding (Delaney, Livingston & Schonberger, 2011). Following the latter authors, this study only considered the criteria of land holding and the term is used referring to farmers who operate on 2 or less hectares of land.

Subsistence farming: This refers to a farming system in which the farmer' objective is to produce for food self-sufficiency in his/her household. According to Pingali and Rosegrant (1995), subsistence farmers use non-traded inputs; those generated by the farm household. Additionally, the system is characterised by a wide range of agricultural products as subsistence farmers do not specialise their production.

CHAPTER TWO
LITERATURE REVIEW

2.1. CAADP as a program for inclusive agricultural markets and food security

With the establishment of CAADP, the African leaders were convinced that the agricultural sector has not been given enough attention for years while being the main source of livelihoods for the majority of the population (Haggblade & Hazell, 2010; Wiggins, 2014). This has led to the weak performance of the sector, laying the continent at the lowest level of agricultural productivity and food self-sufficiency among other developing regions (Diao, Hazell & Thurlow, 2010). Additionally, the past poor agricultural performance has been considered as the main cause of high food imports , hunger and poverty that have persisted in most parts of the continent (Haggblade & Hazell, 2010; Kariuki, 2011). Thus, with particular investment to strengthen the sector, African countries target to reduce poverty and food insecurity but also to end their dependence on food imports. Indeed, special agricultural strategies were needed for many countries to stand global issues including food crisis, high food prices and climate change (New Partnership for Africa's Development [NEPAD], 2010).

The efforts for agricultural transformation in Africa have been supported by various researchers and development agents. For example, Kariuki (2011) stated that Africa has the opportunity to increase its agricultural production for food security by targeting the potential yields of major crops that have not been attained yet. Dercon and Gollin (2014) and Kariuki (2011) added that many African countries have huge uncultivated land and farmers have constraints in accessing agricultural infrastructure and services. They argued that the efforts to agricultural development once invested in resolving these issues should lead to food self-sufficiency and poverty reduction. This has also been emphasised by Wiggins (2014) talking about the transformation of agriculture in Africa as a key condition for growth. In the same way, the World Bank (WB) has highlighted on the place of agriculture in the economic growth of developing nations (World Development Report, 2008). With a particular focus on Sub-Saharan Africa (SSA), the report considered agricultural transformation as a key element to reduce poverty and food insecurity (WB, 2007). This transformation is generally represented as a revolution of agricultural productivity in smallholder production to be accompanied by an increased commercialisation (Dercon, 2009; NEPAD, 2010; WB, 2007). Similarly, Norton, Alwang and Masters (2006) specified that solutions to the complex problem of food-income-poverty that is faced by many developing countries have

links with the transformation of agriculture. Thus, to solve the complex problem of food and poverty, a particular attention on agricultural productivity and commercialisation, remains crucial in the process of the transformation.

Three out of four pillars of CAADP are hence, directly related to agricultural markets and promotion of market oriented production. In the second pillar for instance, the effort to agricultural development is intended to contribute to income growth and wealth creation through improved access to market with a particular focus on rural areas (NEPAD, 2009). Here, the improvement of infrastructure and capacity of commercial and smallholder farmers are planned in order to help the producers to efficiently meet the market requirements. The local and regional markets are the most targeted as they are likely to give higher returns than the foreign export markets (Dioum, 2009). According to McIntire (2014), the countries' efforts are not to be limited to better infrastructure and policies but must also be directed to agreements for easier regional trade in Africa.

In the third pillar, food security was given a priority. In fact, as stated by Vink (2012), the achievement of food security would be a landmark of progress in the transformation of the agricultural sector. With recognition to the role of agricultural commercialisation, the achievement of food security has thus been given a place in CAADP. According to NEPAD (2009), one of the objectives of Pillar 3 is to increase the supply of affordable food through improved agricultural production and market linkages. The fourth pillar focuses on the improvement of agricultural productivity through capacity building of institutions and farmers. Under this pillar, efforts in agricultural research and transfer of technology are recommended to explicitly target smallholder farmers to facilitate their access to markets at lower costs (McIntire, 2014). Furthermore, a developed responsiveness to market conditions among farmers and their supporting institutions such as research, extension or even financial institutions is also highlighted under this pillar.

In spite of the considerable body of literature from the proponents of agricultural transformation in Africa, there are also some pessimistic views on this matter. Among others, Ellis (1998) has emphasised on the poor performance of agriculture in the SSA by stating that the idea that agricultural development will lead to economic growth is too ambitious. He was especially talking about rural families in SSA whose farming has been found not even able to secure their livelihoods. Though the author recognised the importance of agriculture, he emphasised that in the SSA, households which diversified in non-farm activities are better off in terms of income and wealth creation. In the same way, Davis and Bezemer (2003) observed that agriculture alone cannot help

and recommended diversification in non-farm activities for better rural livelihoods. Ellis (2006) argued that using agriculture as an instrument of poverty reduction should consider a number of problem faced by farmers including limited domestic market, growing population that leads to declining land size and price volatility. Diao *et al*. (2010) discussed the different views on the agriculture-led growth being promoted in the continent. They recognised that the past failure of the sector to help countries in achieving poverty reduction has been the cause of sceptical opinions about African agriculture. The authors also emphasised that agricultural growth would be more effective at combating poverty than non-agricultural growth. Their argument was based on the fact that agriculture is more pro-poor as it allows higher participation of the poor in the process of growth. They also highlighted on the importance of agriculture in countries dominated by smallholder farming (Diao *et al*., 2010). Actually, the constraints faced by this category of farmers attracted a lot of attention in the process of agricultural transformation in Africa.

2.2. Smallholder market participation in the current debate

As recognised in CAADP, the smallholder farmers are the centre of the agricultural transformation efforts. This is approved by donors and a number of researchers despite some voices supporting the investment in large-scale production (De Janvry & Sadoulet, 2010). The proponents of this plan to support smallholder farmers pointed out that though the large scale may be having its advantages, it counts for some limited supply chains which are more advanced while smallholders remain in a better position to benefit from the innovations towards commercial agriculture (Delaney *et al*., 2011).

The focus on smallholder farmers is based on the fact that smallholders cultivate a big share of arable land but also on the principle that they are more efficient and only need appropriate technology and access to functioning markets (Collier & Dercon, 2014b; Poulton, Dorward, & Kydd, 2010). Hence the effort to the transformation is to stimulate the growth among smallholders through various interventions including improved technology transfer and market access and participation. This was also emphasised by McIntire (2014) arguing that since the smallholders remain the dominant category of farmers in African agriculture, the problem of their poor productivity must be addressed through provision of improved technology and stimulating their market participation as well as reduction of their transaction costs. In fact with good access to markets and low marketing costs, even smallholder farmers with subsistence orientation seize the

opportunity and embark in commercialisation (Hazell, 2011). Actually, the smallholder farmers respond to market opportunities even better than the large scale farmers (NEPAD,2016).

Focusing on smallholder market participation, African countries have engaged in improving smallholders' access to input and output markets (Bernard & Taffesse, 2012). The reason to this is that smallholder market participation is key element, for the transformation to significantly contribute to the envisioned economic growth (Jagwe *et al*., 2010). The increased market participation of the smallholder farmers is even considered as a basic step towards a fully market oriented farming (Biénabe & Vermeulen 2011). The transformation of the smallholder farming systems can result in the transformation of the agricultural sector in most of the SSA countries. Fischer and Qaim (2012) and Olwande *et al*. (2015) noted that improving the production systems of the smallholders as well as their access to markets is a strategy for sustainable rural development and an effective way to increase rural income. Indeed, literature has emphasised that through higher market participation, the farmers' income and wellbeing will be boosted.

In this sense, De Janvry and Sadoulet (2010) recognised that targeting smallholders in the African agricultural development is the most valid way to improve rural income and consequently solve the issue of poverty in Africa. Besides, the advantages of smallholder transformation and their market participation is even seen beyond the farm households' income. Diao *et al*. (2010) stated that agricultural development (which is accompanied by higher market participation of smallholders) benefit the landless or the net food buyers if the commercialisation is reinforced by productivity growth and decline in food prices. Though the decline in food prices should be considered as a potential disincentive to the smallholders, greater liberalisation and promotion of intra-regional trade were proposed to balance the situation (Poulton *et al*., 2010).

On the other hand, concerns regarding the promotion of smallholder commercialisation have been raised. For example in their paper on agricultural transformation in Rwanda, Ansoms and Rostagno (2012) expressed their pessimism towards the benefits of the smallholder from the change. They stated that though the idea of transforming the sector is to be applauded, the smallholders are likely to suffer for the benefit of large scale farmers. Under this view, the transformation towards market oriented agriculture is likely to increase vulnerability among this group of famers, whose competitiveness would be lower. However, there is another opinion that farmers who are not able to participate as sellers due to the limitations inherent to small farms, would benefit from increased commercialisation of their fellow farmers through off-farm wage

employment (Arias *et al*., 2013). Additionally, the linkage between agricultural transformation and rural livelihood diversification leading to employment creation for farm households and wage workers should not be ignored. Despite the limited knowledge on rural wage work in Africa (Oya, 2013), research in other developing areas showed that households with higher agricultural income are more successful in non-farm diversification (Eapen, 2001).

Another concern regarding the promotion of smallholder market orientation was related to food insecurity which may result from their greater commercialisation. Ansoms (2010) pointed out that as market oriented farming is often accompanied by crop specialisation, this should increase the risks of food insecurity among smallholders. Their dependence on purchased food items increase, making them more vulnerable to volatile food price. Fan *et al*. (2013) also stated that in many developing countries, farmers supply food to the markets and yet remain the poorest and most food-insecure people. This was also observed among tea producers in Kenya where smallholders tend to allocate most of their land to the cash crop and neglect the food crop production (Langat *et al*., 2011). However, a research conducted in Chad showed that higher market access (suggesting higher participation) of the smallholders lead to food security and vice versa (Corsi, Marchisio, & Orsi, 2017).

Controversially, the increase of agricultural income resulting from the high market participation of the smallholders does not necessarily lead to food security. Sometimes, households fail to purchase the needed food as a compensation of what they were producing in their full subsistence system, regardless of the increase in agricultural income (Anderman *et al*., 2014). Hence, the information on linkages between market participation through households' increased income and food security is not conclusive and some literature explained that even the issue of how the income is controlled plays a role in this. This is for example the case of Njuki *et al*. (2011) who explained that the control of income within a household can determine the type of expenditures thus affect the access to food and household's nutritional outcome. With regards to the control over agricultural income, literature showed that when the income is controlled by men it is less likely to be spent on food items which has an effect on food security in the households (Lu, 2007).

Whether the promotion of smallholder market participation is supported or questioned, the fact that these farmers face several challenges is acknowledged by both sides. Actually, they are these challenges which reinforce the pessimistic views of focusing on the transformation of agriculture among smallholder farmers. The point is that agriculture-based growth necessitates the use of

appropriate technology, agricultural finance and logistics as well as marketing abilities which are not easily accessed by the smallholders. So, most of these challenges are institutional related while others are farm related factors. Among them, factors like the limited access to markets and productive assets as well as the socio-economic factors at individual or/and farm level have been cited (Alene *et al*., 2008; Poulton *et al*., 2010). In fact as specified by Arias *et al*. (2013), even under the same conducive policy environment, not all the smallholders decide to increase their level of participation in agricultural markets. Some factors like remoteness from services and output markets, limited access to productive assets and household specific factors constrain these households participation. Actually, these constraints limit some households' opportunity to enter the marketing systems through which they could profitably sell their production (Layton, 2007). Women farmers are particularly known to face most of these challenges undermining their market participation and the benefits of working with other stakeholders in the process of agricultural transformation (Mutenje *et al*., 2016; Fischer & Qaim, 2012).

2.3. Women in agriculture and related concepts from feminist literature

In the process of agricultural transformation, the African leaders gave specific attention to women farmers through various objectives of CAADP. The direct explanation given is that women represent the majority of smallholders, providing unpaid labour in farm production for both households consumption and markets (NEPAD, 2016). They are also recognised as being particularly challenged beyond the common limitations faced by smallholders in the struggle to increase their market participation.

Some of the challenges that are specific to women are for instance their limited access to services and productive assets, particularly land (Quisumbing *et al*., 2015). Also, most women have a lower education level than men and this limits their capacity to successfully deal with the suppliers of financial and inputs services. Additionally, gender norms that influence how women and men farmers must behave are more likely to also affect their market participation. For instance, there are examples where women are not considered as farmers but helpers of their husbands. This limits their opportunities to get services such as training or extension facilities (Twyman *et al*., 2015). Due to their gender roles, women are limited in the way they interact with other actors within marketing systems such as other farmers and traders which constrain their bargaining power and lead to lower returns (Selhausen, 2016; Fischer & Qaim, 2012). In some African countries, women farmers need supportive husbands to participate in farmers' group for collective action

while otherwise they do not participate. In such a case, they are considered as rebellious to their husbands' authority when they decide to participate (Mudege *et al*., 2015). Hence, as Africa targets an inclusive agriculture-led growth, the need for special consideration to women smallholder farmers may not be based on their predominance in agricultural activities only but also to the specific limitations they face in the transformation process.

The situation of women in agriculture, particularly their over-representation in the sector has not only attracted the African leaders' attention but also some feminist scholars. The latter describe this as the "feminisation" of agriculture in developing countries; a phenomenon by which women's contribution in agricultural labour is increasing compared to that of men (Bieri, 2014; De Schutter, 2013). On one hand, the phenomenon is associated with a growing number of rural households headed by women and an increase of non-farm opportunities, sometimes followed by men's migration that cause women to take over male tasks in agriculture (De Schutter, 2013; Deere, 2005). In this situation the feminisation of agriculture can be considered as a consequence of gender inequality in local non-agricultural employments but also a confirmation of the mobility constraint faced by rural women. In both cases, women are left with no many employment options other than working as self-employed in their household farm or as wage workers in their neighbours' farms.

On the other hand, the feminisation of agriculture is seen as a consequence of agricultural transformation. In the efforts to improve productivity and market participation, women from smallholder households increase the time they spend in cash crop production while keeping their roles in household food production. As stated by Jiggins (1998), women are pushed to work longer hours alongside their husbands on cash crops while putting effort to fulfil their gendered role of producing for household subsistence. So for those from dual-headed households, they are not only obligated to supporting their husbands in market oriented production but also have to maintain their home gardens and/or small stock which are traditionally under their management. For women who are heads of households, the exigencies of the new farming systems mostly keep their households in subsistence agriculture or in a low level of market participation. So with the conducive environment and the opportunity to increase smallholder market participation, it is noteworthy that women's share in agricultural labour increases given the changes that accompany the transformation of agriculture. They share the responsibility of producing for markets but their

obligation to produce food for their households remains (Karamba & Winters, 2015; Hill & Vigneri, 2014; Lastarria-Cornhiel, 2006).

With the feminisation of agriculture, the efforts to agricultural transformation can lead to minimal outcomes if the specific limitations to women's progress are not identified and addressed. Though these limitations may not be removed at once (De Schutter, 2013), there is a need to know the conditions under which feminisation of agriculture brings or hinders the desired outcomes from the transformation. Jiggins (1998) argued that as women increase their participation in agricultural production and markets, their other responsibilities including their reproductive work within households are squeezed in the short they remain with. This can have a direct effect on household food security, particularly when women's role as food producers is inflexibly considered. It is also imperative to think about whether the feminisation of agriculture goes together with the participation of women in agricultural decision making. In the literature, the participation of women in such decisions is considered as one of indicators of gender equality (Alkire *et al*., 2013). Indeed, with the transformation of agriculture towards markets the social norms may shape the way women participate in both production, commercialisation as well as the advantage from this change (Doss *et al*, 2018).

2.4. General information on Rwanda

Rwanda is a landlocked country located in Eastern Africa. With a total population of around 12 million and the population density of 512 inhabitants per square kilometre, the country counts one of the highest population densities in Africa (NISR, 2017b; UN, 2019). About 83% of the population live in rural areas where livelihoods mainly depend on agriculture and the average household size is 4.3 (NISR & MINECOFIN, 2014). At national level, 29% of households are headed by women while 30% female-headed are in the rural areas.

Despite the economic growth realised in the last two decades, the country is still challenged in terms of food insecurity and poverty. As from the Integrated Household Living Conditions Survey 2013/2014, 39.1% of the population live below the national poverty line while 16.3% live in extreme poverty (NISR, 2015b). With regard to food security, the Comprehensive Food Security and Vulnerability Analysis by WFP showed that 80% of households were food secure and 20% food insecure in 2015 (Hjelm, Williams, & Moris, 2016). The country is still challenged by malnutrition and the market contributes around 60% of food baskets at household level.

2.3.1. Rwanda's efforts to smallholder market participation

A part from the CIP program, a number of other strategies has been put in place. For instance in the fourth Strategic Plan for Agricultural Transformation (SPAT IV), the government recognise the importance of involving the private sector as well as strong linkages between value chain actors (MINAGRI, 2018). In the National Agricultural Policy, the smallholder households' access to agricultural markets through working value chain has been highlighted. The policy also emphasize on stabilisation of price for agricultural commodities for the smallholder to benefit fully from their participation in the markets (MINAGRI, 2017).

In the previous agricultural policy, MINAGRI (2004) stated that agriculture was identified as a trade sector with potential to be exploited to overcome the limited access to food and food insecurity in general that were results the prevailing poverty in the country. Thus the vision in this policy was "creating a favourable environment to agricultural income generation in order to achieve food security". It is further explained that farmers were to be facilitated to produce for the market and earn the required income to meet their food needs among others (MINAGRI, 2004). The same vision was retained in the second Economic Development and Poverty Reduction Strategies (EDPRS) where the government considered that households need to generate enough income to access nutritious and quality food (MINECOFIN 2013). Here, the importance of staple food production is recognised for food and income to smallholders, but shifting to high value market crops and farm-diversification is seen as a priority.

Similarly, MINECOFIN (2013) in the second Economic Development and Poverty Reduction Strategies (EDPRS) also recognised the transformation of agriculture as a key element to the reduction of poverty. The government emphasised on rural development and envisaged to reduce rural poverty from 44.9 % to below 30% by 2018. Increased agricultural productivity and better linkages to markets are among the strategies to achieve this target. The cost of doing business was also to be reduced to facilitate private investors in agriculture and other sectors. This was planned as one way to increase employment opportunities in which the transformation of agriculture is expected to play a crucial role. Hence with the efforts to facilitate the investors, for the first time in SSA, Rwanda was the first country in the World to undertake business reforms in 2010 (Ansoms & Rostagno, 2012a).

2.4.2. Women farmers and the transformation of agriculture in Rwanda

Previous research in other developing countries like India, Bangladesh and Nigeria have revealed regional or gender disparities in terms of agricultural employment and productivity (Shafiqullah, 2013; Reddy, 2011; Ogunlela & Mukhtar, 2009). In Rwanda, equality between men and women is at the heart of all efforts to the country's development. Remarkable changes in laws, establishment of gender-sensitive policies and strategies testify to the high commitment by the government to gender equality. Among the main changes include the Constitution of 2003 in which men and women are declared to have equal rights with a quota of at least 30% reserved for women in decision making positions (GoR, 2003). Land reforms including the Land inheritance law of 1999 and Land policy of 2004 in which women were respectively given rights to inherit and to have equal ownership with men has also been another great achievement in gender equality (Daley, Dore-Weeks & Umuhoza, 2010; Daley & Englert, 2010).

Regarding the agriculture, policies and strategies gave a particular consideration to women farmers as a way to ensure equality between men and women in the process of transformation. These are mainly the National Agricultural Policy (NAP), the Economic Development and Poverty Reduction Strategies (EDPRS), Strategic Plan for Agricultural Transformation (SPAT) and recently, the Agriculture Gender Strategy (AGS). In the NAP for example, the government acknowledged women's growing contribution to agriculture by supplying labour for production, harvesting and processing in addition to their household reproductive works. They are therefore targeted for higher productivity and economic independence which are to be attained by facilitating them to access credit, land, appropriate technologies, training and remunerative employment (GoR, 2004).

In the AGS, the key point discussed is about women' need to access and control productive assets. Their limited access on these assets is mentioned as a cause of their few possibilities to work with financial institutions for example. Additionally, the ministry of agriculture recognised that compared to men, more women need access to market and the plan in AGS is to ensure equal access to market information while facilitating women to seize emerging agribusiness opportunities (MINAGRI, 2010). This is also found in EDPRS (I and II) and the SPAT (I-III) where gender equality is highlighted as key element to improve livelihoods through market oriented agriculture, especially in rural areas (MINAGRI, 2013; MINECOFIN, 2013).

2.5. Other research conducted on smallholder market participation

There is an extensive literature on agricultural transformation and the participation of smallholder farmers to markets. Some are review papers mainly discussing the past experience of African agricultural development or the current attempt to the transformation while others are basically from researchers' analysis of the situation. Both categories of literature were particularly used to understand the background situation of agricultural transformation in Africa and how the integration of smallholder farmers is considered.

There is another group of literature which are area-specific studies and they mostly used primary quantitative data, treating various topics. Among these studies, some analysed the determinants of smallholder market participation. These are for instance the studies conducted by Asfaw *et al*.(2012) using a Logit model to estimate the determinants of inputs and outputs market participation among smallholder producers of pigeon peas in Kenya. The study highlighted that young and female-headed households had higher probability to engage in pigeon peas commercialisation. Mmbando *et al*. (2015) used a Heckman model to analyse the factors influencing market participation among pigeon peas and maize farmers in Tanzania while Ndoro and Hitayezu (2014) employed Double-Hurdle model to investigate the determinants of smallholder participation in livestock market in South Africa. Zuwarimwe and Mbaai (2015) and Musah *et al*. (2014) also analysed the determinants of smallholder market participation respectively Namibia in Ghana.

Other studies analysed the market participation of smallholder farmers or their commercialisation and its effects at household level. They are dominated by studies on the effect of commercialisation on food security but some looked at its effect on poverty at household level. Additionally, few studies examining the linkage between smallholder household commercialisation and rural non-farm employment have been found. The next sections summarise some examples from each of these papers plus those which particularly investigated women smallholders.

2.5.1. Effect of agricultural market participation on smallholders' welfare

Among the studies on effect of agricultural commercialisation is Anderman *et al*. (2014) who analysed the effect of cash crops production (palm oil and cacao) on food security among smallholders in Ghana. The authors used a Mixed-methods approach and looked at food availability, food access and food utilisation. The results showed a negative relationship between

cash crop production and each of the three aspects of food security. Qualitative information helped to identify factors like increased food price, low purchasing power and competition between food and crop production as underlying causes of this negative effect. Asfaw *et al*. (2012) also studied the impact of smallholder market participation on food security in Kenya. They looked at food access and utilisation components and used propensity score matching (PSM) technique. The Household Food Insecurity Access Scale (HFIAS) and the Household Dietary Diversity Score (HDDS) were used as proxies of welfare. By comparing participants and non-participants, the study revealed a positive impact of output market participation on food security status of participants. Similarly, Corsi *et al*. (2017) investigated on the factors determining market access and its links with collective actions, land but also with food security among smallholders in Chad. Using a Multinomial Logistic regression, the authors found a circular relationship between market access and food security. The access to market improved food security and vice-versa.

On the other hand, Mitiku and Bely (2014) assessed the level of commercialisation and its effect on rural poverty in Ethiopia. They used Market participation index, Poverty index and a Logit model. The crop commercialisation was found low (39%) and it has a negative but insignificant effect on poverty. Other socio-economic factors like gender, age, access to credit, annual farm income, education and distance to market place were found significantly and negatively affecting poverty. Women headed household were more likely to be poor compared to men headed ones. Aku *et al* (2018) have also analysed the relationship between market participation and smallholder farmers' income in Tanzania. They specifically looked at the impact of market access through farmers' organisations on income of vegetable producers. Using Propensity Score Matching (PSM) methods, the authors found that farmers who accessed vegetables market through organisation had more income that those who did not commercialise through groups. Other factors such as gender of the household head, size of landholding and distance to the market had significantly related to farmers' access to market through organisations.

2.5.2. Agriculture and linkages to rural employment

Kumar *et al*. (2011) analysed the determinants of rural non-farm diversification and its implications to poverty in India. By using Multinomial Logit and Log-linear models, agricultural sector was found to be the first employer. However, they found that non-farm employment, commercialisation; literacy and rural wages were significant determinants of poverty reduction.

They concluded that agricultural growth is not sufficient to reduce the incidence of rural poverty (especially among the landless) and recommended diversification to non-farm employment.

Bezu and Barrett (2012) also analysed the dynamics in rural non-farm employment (RNFE) in Ethiopia. Their main interest was to understand the movements between low-return and high-return RNFE as well as their relationships with agriculture. Using Multinomial Logit models, they found that households participating in high return RNFE got more assets and better livelihood. Wealth, access to saving and labour were the significant determinants of shifting to the latter category of RNFE. In contrary, any shock to agriculture such as pests and crop disease was found likely to cause movement from high-return RNFE to low return RNFE.

Using the Sustainable Livelihood Approach, Jacobs and Makaudze (2012) studied rural livelihoods in South Africa. They employed both quantitative and qualitative indicators and found that farm and non-farm households combine a number of livelihood strategies including farming, wage working and social grants. Land was found to play a significant and positive role in building assets such as land, livestock and financial assets at household level. Agricultural wage worker household, who were mainly headed by women were found more likely to be poor in terms of asset accumulation. The authors recommended a land-based livelihood strategy.

Finally in the context of Rwanda, Hitayezu *et al*. (2014) analysed the determinants of farm households' participation in non-farm rural employment. The study was based on households' time allocation theory and the analysis was done using a Double-Hurdle model. Households' participation in RNFE was found to be positively influenced by female-headedness, labour availability, education, social network, access to finance and proximity to rural towns. Age, land productivity and distance to market were found to decrease the time allocated to non-farm activities. The authors recommended an improvement of education level with focus to women and the poor. For the achievement of higher growth, the study recommends the government to recognise and develop the complementarities between agricultural and non-agricultural sector. They also called for more focus on the development of both agricultural and non-agricultural sector as these sectors are highly interlinked.

2.6. Research with a focus on women smallholder farmers

A limited number of studies have specifically focused on women farmers in their objectives or research questions. Among these include Zakaria (2017) who analysed the determinants of smallholder women farmers' participation in the decision making regarding cash crop production

in Ghana. The author used a Probit model and found that women's participation in cash crop production is positively influenced by their participation in household production decisions, control over productive resources and control over use of household income.

Similar results were found by Lenjiso *et al*. (2016) in their study on relationship between women's intra-household bargaining power and smallholder household participation in milk market in Ethiopia. In their study, they considered wives' ability to control a proportion of household income as an indicator of their bargaining position. They used a Mixed-method approach involving qualitative interviews and a quasi-experiment and a Propensity Score Matching for quantitative data. Their findings showed that though the milk income shifts to the hands of men as households start to participate in the market, the wives' bargaining position has increased among the market participants compared to those from non-participating households. So, in market participating households, wives had control over a share of income and men indicated that this power was given as a recognition for their reproductive responsibility (household maintenance). The study concluded that women's bargaining position was stronger in these households.

While women's contribution seems to have been considered in the study by Lenjiso *et al*. (2016), a different research on crop production in Ethiopia revealed the contrary. It was conducted by Ogato, Boon and Subramani (2009) on the roles of women and men in crop production and management. By using descriptive statistics and inferences, their findings indicated that though both women and men are responsible of farming activities, women were found to work more than a double of the time used by men on fields. They also found that the women's triple role of working in productive community works and reproductive tasks are undervalued in the study area.

Ibnouf (2009) also studied the role of women in providing and improving food security in Sudan. The study used a mixed method combining field survey, secondary data and desk research. The findings revealed that women play a greater role in food security than men. They work longer time than men in activities related to food and nutrition security. Women have also diversified in off-farm employment especially in agricultural processing which contribute to the welfare of households. Their capacity to expand their income generating activities and enhance food availability was found limited by limited access to credit, their time poverty, limited skills, low level of education and marketing problems. The author recommended elimination of women discrimination in the formulated policies as well as strengthening their at grassroots level.

Similar results on the difference of market participation between farmers based on the sex of household heads was also found by Kamunye (2016) in his research on bean marketing in Rwanda. He mainly looked at the determinants of market participation among male and female headed households. His findings showed that first the proportion of female-headed households that participated to bean market is lower compared to those headed by male. Second, the determinants of participation were slightly different. In the case of the female-headed households, years of education, land under bean crop, access to credit, household size group membership were positively related to their participation to market. Whereas in male-headed households, the significant and positive variables were marital status and total land size. In both cases, age was negatively and significantly related to households' market participation.

Marenya *et al*. (2017) studied the issues related to marketing by comparing the participation of women- and men- headed households in maize market. Their objective was to examine the drivers of gendered market participation and the gap of participation and its causes. The study found out that households headed by women were more than twice likely to be net buyer of maize while those headed by men were more likely to participate as net sellers of maize. The results showed that household size, credit, membership to farmers' organization, proximity to the market and land size were the significant causes of the gap in maize market participation. The authors recommended gender-sensitive policies to address the inequality in agriculture but also to improve women access to various assets including land.

With regards to women's access to assets, Bhaumik *et al.* (2016) analysed the impact of women's land ownership on participation in high value farming in Malawi. Their findings showed that the income from high value crop decreases when the land is owned by a woman while the probability to produce high value crops increases when the land is owned by a man. The study specified that though ownership of land may be important, other aspects like access to market and other resources like hired labour and capital for the their household welfare.

A similar observation was made by Bayisenge, Höjer and Espling (2015) in their study on women' s land right and the experience of local implementers of land tenure reform in Rwanda. They used a qualitative approach and aimed at analysing the experience of land titling and registration. Major issues related to women's right to land were polygamy and inheritance. In cases of polygamous unions, husbands resisted to register the land on wives with whom they had official union while in some families the members could ignore that women and girls also have rights to

inherit land and that caused conflict to the local implementers of land registration. The authors also found that despite the commitment of policy makers to ensure equal access to land in Rwanda, the implementation may not be very easy given the area-specific customs. They also concluded that giving land titles to women does not guarantee their automatic benefits from these titles as their decision-making over land may not automatically improve.

2.7. Identified gaps in the reviewed studies

In general, there is extensive literature on agricultural transformation and market participation in Africa and it has its own merit. However, there is still a knowledge gap to be filled. First, the socio-economic conditions under which women farmers contribute to market participation of smallholder households remain under-researched. On one hand, most research that discussed women in agriculture have limited their analysis on the comparison of female and male headed households. Others, by mainly focusing on household head again, have made specific contribution in highlighting the constraints faced by women in the transformation process. They mostly discussed these constraints as a result of gender inequalities faced by women farmers but these inequalities were often taken from the conventional knowledge or from limited primary data. On the other hand, the place of individual characteristics of women as a category of farmers that may be influencing smallholder households' behaviour has been neglected. However, with the current trend of feminisation of agriculture, it is imperative to understand what is needed to unfold market orientation through women farmers too. Indeed, recent literature has questioned the approach of focusing on household heads while researching on women or gender in agriculture. They warn that considering only heads of households is to ignore the greater proportion of women farmers who contribute under male headship (Doss *et al*., 2018).

Second, the effect of market participation in smallholder households is highly debated and the findings seem not really conclusive as they tend to vary depending on geographical regions or crops. For instance, while the effect on food security was found positive in Kenya a separate research showed its negative effect in Ghana. Additionally, empirical research on the effect of market participation on other source of rural livelihood such as on-farm and non-farm employment is rare. Few studies which looked at this area mainly focused on rural non-farm employment but the on-farm wage work or other kind of informal employment that can be created by a smallholder household received little attention. This calls for more context-specific and diversified studies on the effects of agricultural commercialisation in smallholder households.

Finally with some exceptions, studies of smallholder market participation mainly used quantitative approach, sometimes discussing the gender related issues based on the effect of the characteristics of the household head. The limitation of such studies is that they missed the personal perceptions or experiences of the respondents themselves to better understand their situation. So complementing quantitative survey with qualitative data would bring richer information on this particular topic for more informed interventions.

2.8. General contribution of this study to the body of knowledge

The contribution of the present study is mainly of research design and analytical aspects. From the beginning, the study was designed in a way that women from smallholder households were considered as individual and key contributors in their farms. This is thought so regardless of the headship of their households. This perspective allowed to avoid the problem of omitting the major share of women in male-headed households and it is particularly relevant since even in those households, women are (becoming) more involved in farming.

The consideration of individual farmer from smallholder households has been also used by Doss and Morris (2001) in their gender study of innovations adoption among maize farmers in Ghana. They compared adoption among individual women from female-headed households, individual women from male-headed households and men from male-headed households. The authors also mentioned the importance of the household head in decision making on farming systems. Hence, this study kept headship along other household characteristics which are hypothesised to play a role in market participation. Zakaria (2017) used the same approach when studying the drivers of smallholder women's participation in cash crop production in Ghana.

Besides focusing on individual women farmers, the study used a mixed method research design in which quantitative and qualitative methods are used from data collection to results presentation. In their introduction to Mixed Method Research (MMR) in agricultural economics, Akimowicz *et al*.(2018) noted that the use of this approach is very recent and few studies have integrated quantitative (econometric modeling) with qualitative methods. In this field, researchers have commonly used quantitative methods while MMR has been widely adopted in other disciplines and enquiries like in sociology, psychology, organisation research, feminist economics, public policy and program evaluation in both published papers and doctoral theses (Guetterman, 2017; Starr, 2014; Small, 2011).

As suggested by Akimowicz *et al*. (2018), agricultural economists would gain from using MMR as it can help them to deepen their analysis. Of course, there are cases where using quantitative approach only would be sufficient. This is especially when the interest is only in understanding the relationship of variables or comparing the performance of groups towards an particular outcome (Creswell & Plano Clark, 2018). In this thesis, the mixed method approach was used as an added value to the quantitative method which is common in the corps of research on women farmers. Actually, it is almost implausible to research on women in agriculture without looking at gender related issues and the latter cannot be completely quantified and modelled. They are narratives of experiences and perceptions of situations which can better be captured through qualitative tools. Hence the strength of having used the MMR in this study. The qualitative part has actually helped to better understand some causal relationships resulted from the quantitative.

2.9. Theoretical framework

The concepts of "*feminisation of agriculture and the feminisation of responsibility*" guided the conceptualisation and design of this research. The idea was to bring out the position of women in the process of agricultural transformation as well as the conditions under which they can improve households' market participation and its outcomes in terms of food access and on-farm employment. The concepts particularly guided the choice of focusing on women farmers but they also served as a framework for the qualitative part of this study. However, as women operate within farming households, the influence of other adult members specifically a husband is not ignored. Therefore, for the quantitative part of this study, there was a need for a household model that allowed to capture the position of women in households' decisions, the outcome decisions as well as households' characteristics that are involved. In the following sections, relevant household models are explained and the cooperative bargaining model of the household was found suitable to guide the framework of this part of the study.

2.9.1. Agricultural household theory

This theory is based on the idea that production, consumption and labour supply are three linked dimensions in farm households. According to Singh *et al*. (1986) considering a farming household that participate in markets , as in the conventional theory of demand and supply would be ignoring the complexity of agricultural households. The household is at the same time a consumer but also a producer of agricultural goods and services, needed for the maximisation of its utility. As a production entity, a farm household decides on how to allocate inputs including labour while as a

consumer, it has to allocate the agricultural income and other income for the consumption of agricultural commodities and services (Taylor & Adelman, 2003). Thus, any intervention or change in agricultural policy is likely to impact on household's production, labour supply and demand as well as consumption patterns (Singh *et al*.,1986). The explanation to this is that for any production cycle, a farm household seeks to maximise its utility function below, as adapted from Singh *et al*.(1986) and Zhan *et al*. (2012):

$$\boldsymbol{Max\ U(Q_h, C_m, L_h; X)} \quad \text{.....Equation 1}$$

Where: Q_h denotes an agricultural staple produced by the household, C_m market purchased goods, L_h measures time for leisure in the household and X are fixed Utility shifters (household characteristics).

The maximisation of the above function is subject to three constraints namely the agricultural technology, income and time as:

$$Q_T = f\left(L_f, L_m, K_m, K_h\right) \quad \text{.....Equation 2}$$

$$I_h = \sum_{j=1}^{n} p_j Q_j + w_{of} L_f + I_{tr} - \sum_{m=1}^{z} p_m K_m - w_m L_m \quad \text{.....Equation 3}$$

$$T = L_{fa} + L_{na} + L_h \quad \text{.....Equation 4}$$

Where:

In Equation 2, showing the agricultural production function, Q_T is the output quantity under the technology constraint, L_f denotes family labour, L_m stands for household labour demand, K_m and K_h stand respectively for tradable and non-tradable inputs (fertiliser, land, seed).

In Equation 3, the budget constraint, I_h stands for total household income, Q_j is agricultural production w_{of} is the wage/salary for supplied for off-farm activities, L_f is the labour supplied by household and I_{tr} is the income from transfers and other external income. w_m stands wage for hired labour, p_j and p_m are respectively the market prices of agricultural outputs and tradable inputs.

In Equation 4, representing the time constraint, T denotes the time endowment of household labour, L_{fa} indicates the labour involved in household farming activities, L_{na} stands for the labour supplied for off-farm activities (farm and non-farm) and L_h is leisure time.

2.9.2. The recursive agricultural household model

In the literature on agricultural household theory, two models namely the recursive and the non-separable models are used. In the recursive model, the decisions about production and consumption are assumed to be independent from each other. The household consumption preferences are

considered as being not connected to the production decisions and they are not expected to affect each other (Le, 2010). In their production and resources allocation, farmers are assumed to behave in a way to maximise profit and achieve at least its largest level (Le, 2010; Singh *et al*., 1986). Actually in this case, the markets are assumed to be perfect and the farm households have access to all information needed for making efficient decisions. Additionally, due to the assumption of fixed wage (w_m) and price (p_j); family and hired labour, own farm and market agricultural product are perfect substitutes (Zhan *et al*., 2012;Taylor & Adelman, 2003). Thus, the household is indifferent from consuming a proportion of its production that could be sold or consuming the same commodity bought from market and this also applies to labour supply and demand. Hence with a recursive model framework, the household production would be oriented to separate and independent profit maximisation as a producer, and utility maximisation as consumer, as there is no difference between those bought or own produced agriculture produces.

Though the recursive model has been widely used, its assumptions make it less appropriate for developing countries where the markets are not competitive or even sometimes missing (Mather *et al*., 2013; De Janvry & Sadoulet, 2006). Moreover, Singh *et al*. (1986) specified that when households consume all its outputs instead of selling, the preferences and variable prices (sale and purchase price of a commodity are different) are considerable. In such cases, a non-separable model is preferred over the recursive one (Mather *et al*., 2013; Singh *et al*., 1986). For the purpose of this study the recursive model is less appropriate, given its assumptions and the research context.

2.9.3. The non-separable agricultural household model

Contrary to the recursive model, the non-separable model assumes the household's production decisions (choice of inputs and outputs for instance) to be affected by its consumer characteristics such as the preferences and demographic composition (Le, 2010; De Janvry & Sadoulet, 2006). It also considers the shadow prices and wage at household (virtual prices of own production and labour) which could be less or higher than the market prices of agricultural products and labour. As the price at farm-gate is assumed to be different from the market price, a household may decide to keep a proportion of (or all) its production. The linkage between production and consumption is no longer the income but also the preference or the size of the family for instance. Similarly, the farm households may decide to use family labour or hired on-farm workers depending on functions of wages and production. Hence the decision process in the household becomes circular, as production affects consumption and consumption affects production.

The model has been widely used to understand farm households' behaviour in developing countries. For example, it has been used to analyse labour allocation in South Africa, Kenya and Zimbabwe respectively by Lovo (2012), Mathenge and Tschirley (2015) and Matshe (2004). In their studies on food security, Louhichi and Gomez (2014), Mutenje *et al*. (2016) have used it in Sierra Leone and Malawi, respectively. Also Saha and Stroud (1994), analysing household decisions on consumption, storage, saving and labour allocation in India as well as Afari-Sefa (2010) in his study on linkages between production, consumption and livelihoods in rural Ghana have adopted the same model.

2.9.4. The non-separable model and smallholder market participation

The non-separable model has a considerable place in the studies of household market participation and orientation. As mentioned above, the non-separable decisions occur when the market price of an agricultural product is different from the value of that product at the household level (shadow price). Preferences, constraints to households and transaction costs increase this difference and influence farm households in their decision to sell or keep their production for consumption (Löfgren & Robinson, 2003). Preferences have an influence when the purchased good is considered as an imperfect substitute of the own produced good while constraints and transaction costs originate from weak or absent institutions (Löfgren & Robinson, 2003; Sadoulet & De Janvry, 1995). In any situation when the value of the own production is lower than its market value, the household decides to keep it for self-sufficiency.

In contrast, when the value of own production is equal to its market value, the household will participate in the market. With the non-separable assumption then, the household's Utility maximisation (Equation 1) is subject to an extended set of constraints as shown below from De Janvry and Sadoulet (2006) and Zhan *et al*. (2012). Equation 3 becomes:

$$I_h = \sum_{j=1}^{n} p_j Q_j + w_{of} L_f + I_{tr} - \sum_{m=1}^{z} p_m K_m - w_m L_m - TC \quad \text{.....Equation 5}$$

Where: TC comprises the fixed transaction costs such as the information costs and the variable transaction costs like the transport costs.

For the constraints, we have an additional equation:

$$m_k \leq M_k \quad \text{.....Equation 6}$$

Where: m_k is the vector of marketed surplus and M_k is the value of the constraints to commercialise product *K*. The preferences are captured through X of Equation 1 and, Equations 2 and 4 remain the same.

2.9.5. The Becker's theory of allocation of time

In his paper on theory of allocation of time, Becker (1965) acknowledges that households play both roles of producing and consumption of commodities. In the theory of allocation of time, the household combines time and purchased goods in the production of commodities with an objective of satisfying its utility function (Becker, 1965). The commodities produced would be agricultural or non-agricultural and the households choose the best combination of the time and market goods in a way that maximise their utility. The combination is in accordance to the household's production function but in emphasizing on the time allocation, Becker presented it as follows:

$Z_i = f(X_i, T_i)$……...Equation 7

Where: Z_i refers to the commodities of interest, X_i is the vector of marketed goods used in production of the commodity *i* and T_i is the time allocated to the production of the commodity.

Using Becker's model in agricultural context would particularly make sense in a situation where quantitative measures of time such as hours or days spent in subsistence and market oriented production are available. The model can also be applied in studies interested in the productivity of the hours of work which is not the case for the present study. Additionally, Becker's theory on time allocation falls in the category of the unitary household models in which the intra-household relations is not considered. This model like the farm household models reviewed above, takes the household as a single unit in which all the household members have same preferences and their choices are made by the household head. In the context of this study, where women farmers were either head or spouses of the household head, ignoring the intra-household relation would be misleading. Actually, though the interviewed women were knowledgeable farmers, one would not ignore the unbalanced power relation that could exist in dual headed households. However, his other works namely his theory on social interactions in Becker (1974) and division of labour in households (Becker, 1993) had indirectly guided the conviction of using a collective/bargaining household model for this study.

2.9.6. Collective models and gender effect in farm household decisions

Considering a household to behave as one member would be oversimplifying the complex environment in which households' decisions are taken (Mattila-Wiro,1999). The unitary models could be more appropriate in a case where the household head is considered as a dictator or the other members are altruistic (Mattila-Wiro, 1999). According to Becker (1974), the household's utility-in the unitary model is the same as that of the head, not because he or she exercises

dictatorial power over other members but because he or she decides in a way that satisfies the utility of other members. In other word, the head of the household is a benevolent person who takes into consideration the preferences of other members. The increase in utility of a non-head member of the household would increase the utility of the head and consequently increase that of the family, which opens for possibility of bargaining among the members (Becker, 1974; Chiappori & Lewbel, 2015). However, the unitary models do not explicitly incorporate the members' ability to bargain, though crucial in decision making process (Doss, 2011). This shortcoming led to the rise of alternative approach of modelling households' behaviour using collective household models.

The collective models focus on individual members rather than taking all the households as a single decision making unit. They are called collective or bargaining models and they are particularly applied in decision making between spouses, for instance seeking to understand how the preference of one spouse affects the (collective) household's choice (Alderman *et al*., 1995; Mattila-Wiro, 1999). Contrary to the unitary models, these models account for gender effects in the households' decisions and they are distinguished in two categories namely the cooperative models and the non-cooperative models.

In the non-cooperative models, women and men have separate economic and budget decisions and these decisions are made independently. The action of one determines the action of the other and the only link between them is the transfer that can be made by one of the spouse (Alderman *et al*., 1995). In the non-cooperative models, the spouses stay together but they neither pool their resources nor coordinate their economic actions (Chen, 2013). In the agricultural sector, the example of a non-cooperative bargaining relationship was found by Jones (1983) cited in Doss and Meinzen-Dick (2015). In Jones' study in Cameroon, women decided to contribute less of their labour to rice production and shifted it to production of sorghum where they perceived more compensation. They felt that men were not compensating them sufficiently, for their contribution in rice production. A similar finding was observed in chili pepper and French beans production in Kenya (Dolan, 2001; Rubin & Manfre, 2014).

In the cooperative model, the approach is slightly connected to the unitary model. The spouses though considered in their individuality, benefit more when they form a household than when they are not together. In the cooperative model, each of the spouse has his/her interest and preferences but they care for each other and decisions involves a bargaining process between them (Vermeulen,

2000). Thus for either of the spouses, the gain from this cooperative relation depends on his or her bargaining power which is a function of personal and household characteristics as well as the extra-households factors including policies and law (Alderman *et al*., 1995; Doss, 2011). In the analytical process, households that have both a man and a woman are frequently considered but leaving out those headed by women would limit the understanding of the various aspects of women's bargaining power (Doss, 2011).

In studies related to women's bargaining power, a review by Doss (2011) gave a number of indicators including women's ownership of land and non-land asset, women's high participation in household's decisions, access to information and kinship network among others. The author also highlights some of the households' outcomes that have attracted the attention of researchers, interested in knowing how women's bargaining power impacts these outcomes. These include consumption outcomes and production outcomes such as sales and input use decisions, labour outcome among others.

2.10. Conceptual framework

The situation of smallholder households in Rwanda fits in with the non-separable farm model as they are at the same time, the suppliers and the consumers of agricultural products and labour. Indeed, the model is recommended in cases where smallholder households are in transition from pure subsistence to a full market orientation (Barnum & Squire,1979). However, this study focused on women farmers as individual actors from these households and based the conceptual framework on the cooperative bargaining model.

The households' outcomes are output market participation, food access and on-farm employment creation. Under the influence of the current institutional environment and the need of making profit out of farming, women farmers are hypothesised to bargain for households' participation to output market. Their institutional environment is classified into physical and institutional infrastructure, being an incentive or a barrier to their households in the process of market orientation (Barrett,2008). The physical infrastructure includes households' proximity to good roads and markets while institutional infrastructure consists of the access to extension services, agricultural trainings and membership to groups. Additionally, women's participation in the marketing system is considered as a proxy of access to market information which would also influence on the household's decision in the market. Women who operate in a favourable institutional setting are more likely to influence their households' decisions to participate in output

market. This study recognises possible constraints (the so-called market failures) which may limit households' participation to output markets. These constraints are not crop specific but are individual or household specific (De Janvry *et al*.,1991; Omamo, 1998). Besides, the socio-cultural environment of women farmers as well as the socio-economic characteristics of their households such as households size, land size, marital status or education level of these women give them a certain power in the decision making process within their households.

Women's participation level in production and income decisions were used as indicators of bargaining power among these women (Doss, 2011; Alkire *et al*.,2013).

As the households participate, the agricultural income is expected to increase and result to food access among households. In fact with the *profit effect* (Singh *et al*., 1986), the household that participate to output market is able to purchase food items. At this level, women would favour the decision that improve their household's food security. Finally, as households generate agricultural income through output market participation, women's time constraint become more relaxed and the households start to hire labour to substitute some of the family labour. Hence, as highlighted by Pingali (1997), opportunities of collective actions as well as good trade-based interactions enhance these welfare gains (Barrett, 2008).

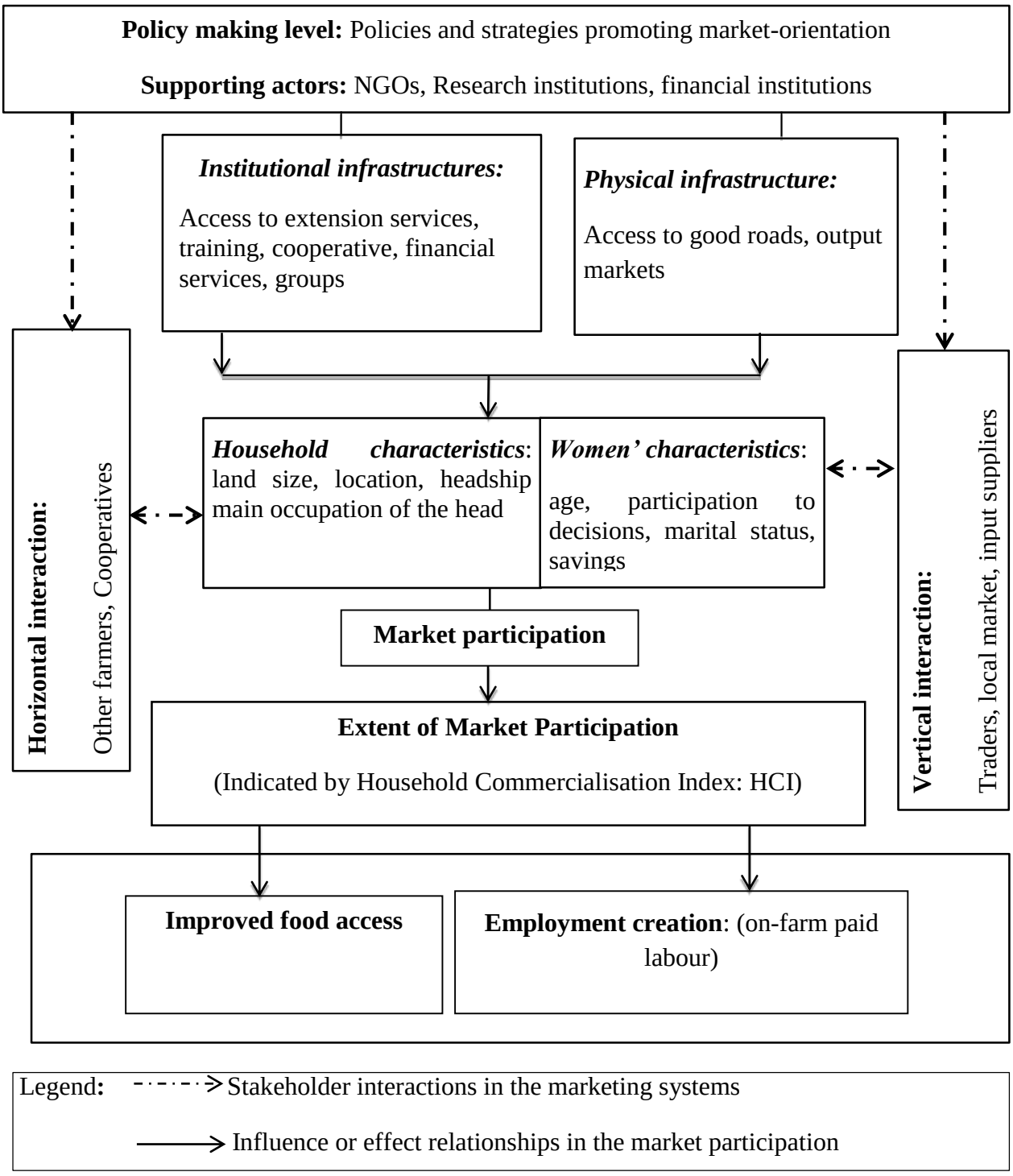

Figure 1: Conceptual framework

Source: Adapted from Barrett (2008), Doss (2011) and Doss and Meinzen-Dick (2015)

CHAPTER THREE
METHODOLOGY

3.1. Study area

This study was conducted in three out of five districts of the Northern Province of Rwanda, namely Burera, Musanze and Gakenke (with dashed lines in Figure 2). Musanze is located in the agro-ecological zone of Birunga at 29°36'23.84" of longitude and -1°30'27.47" of latitude. With an elevation of 1890 meters above sea level, the district is the most populated with 694 inhabitants per sq.km on 540.4 sq.km (Musanze, 2015; NISR, 2015a). Burera is the bordering district to Musanze in the West, and the republic of Uganda in the North. It is located in Buberuka highlands with 339,200 inhabitants and a population density of 522 inhabitants per sq.km (Burera, 2015). Gakenke is one of the three districts selected for this study and it is located in the southern borders of Musanze and Burera, the district is extended on 704.06 sq. km. It is the second district in the North having low population density of 480.9 inhabitants per sq.km after Gicumbi (Gakenke, 2015; NISR & MINECOFIN, 2012).

According to NISR and MINECOFIN (2012), agriculture is the main economic activity in all the three districts. In fact, the majority of the population with 16 years and above reported being self-employed farmers during the Integrated Household Living Conditions Survey of 2012. They were respectively 58%, 75% and 80% of the active population in Musanze, Gakenke and Burera (NISR & MINECOFIN, 2012). Agriculture was followed by trade as the latter covered 8%, 5% and 9% of the sources of main jobs in Musanze, Gakenke and Burera respectively. According to the same survey, farm and wage work were the two most important sources of income in all the considered districts.

Specifically for agriculture, the soils are generally favourable for farming and the average rainfall is the highest (1500mm) in the Northern Province compared to the other parts of Rwanda (Rwanda Environmental Management Authority [REMA], 2015). The average land is 0.45 Ha, 0.62 Ha and 0.39 Ha in Musanze, Gakenke and Burera respectively. The mean share of crop commercialisation is 21.4% in Musanze while the national average is 20.9%. In Gakenke and Burera districts,19.2% and 22.4% of the household agricultural production was sold, reference

taken from 2012 (NISR & MINECOFIN, 2012). Compared to others in the Northern Province, the three districts were at the top level in terms of commercialisation of agriculture.

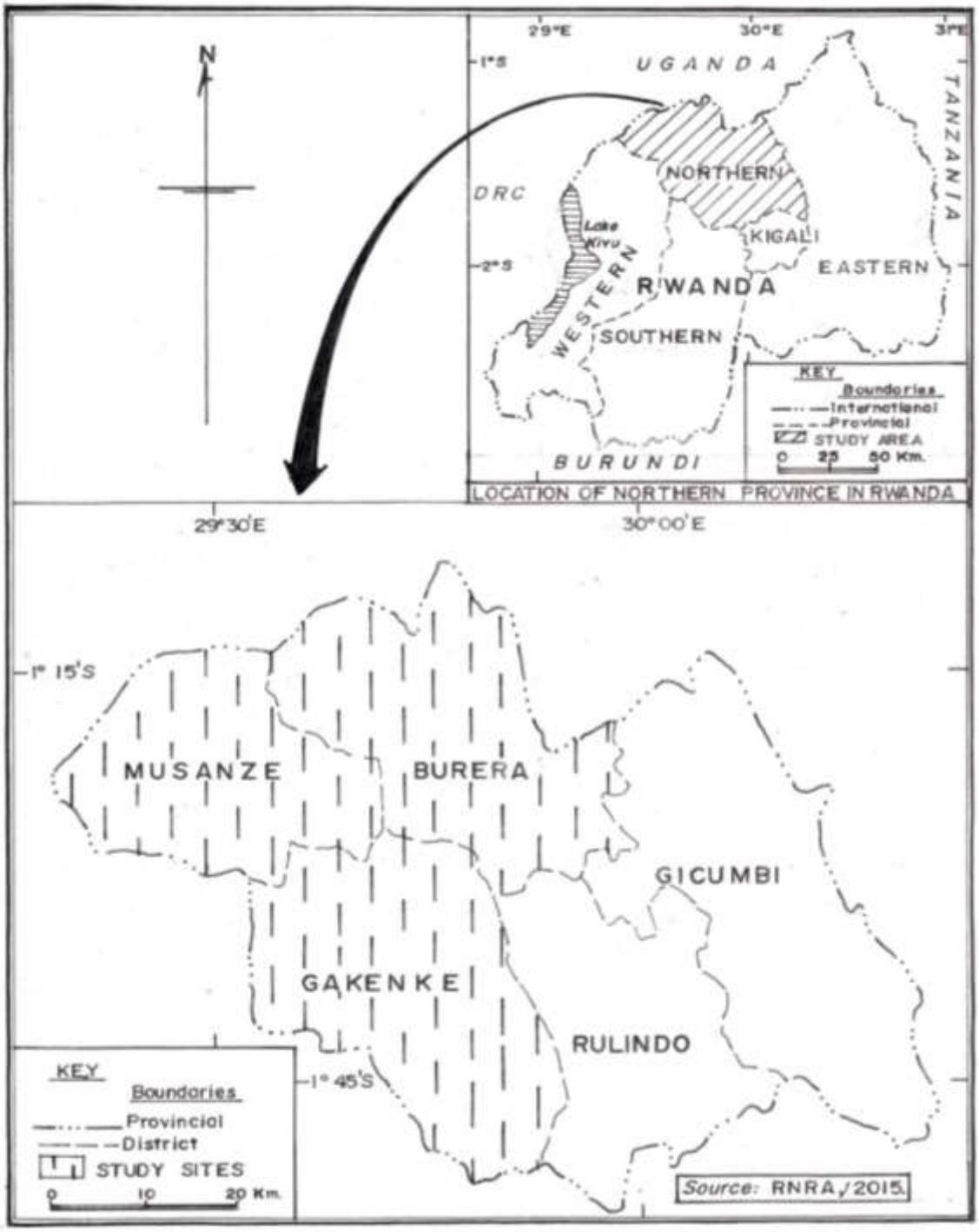

Figure 2: Map of Rwanda showing the study area

3.2. Research design

This study used a mixed method research design that combined a quantitative survey and Focus Group Discussion (FGDs). It followed an explanatory sequential design in which quantitative data collection and preliminary analysis was done and followed by qualitative data collection. The choice of this design was inspired by Creswell (2009) who described that a sequential explanatory design is useful when seeking to interpret and give detailed explanation on quantitative findings particularly when the latter have some unexpected features. In this study, the design have been chosen because of the nature of the research question that mainly looked at women farmers. Understanding women's experiences on the agricultural transformation was one of the core parts of this research, which required use of qualitative tools (Starr, 2014). Thus, given the mixed nature of the research question, this use of quantitative and qualitative method was predetermined and planned from the beginning of the research process and it was implemented in that way (Creswell & Plano Clark, 2018).

On one hand, the survey was expected to analyse the link between households' market participation and socio-economic and institutional characteristics. Thereafter, to determine the effect of market participation on employment and food security. Qualitative method was not robust enough to give all the information collected in the survey. Thus, the mixed approach was found very appropriate to overcome the gaps of each of these methods. Hence, the use of FGDs followed the quantitative survey for a detailed understanding of the specific aspects in the research questions but the design was flexible enough to consider new information emerging from them. It was not used for confirmation but for the sake of complementarity between both methods (Small, 2011).

3.2.1. Sampling procedure

In this study, a multi-stage sampling technique was used. In the first stage, three (3) districts of the Northern Province of Rwanda were purposively identified. In the second and third stages, two (2) sectors from each of the districts and two (2) cells from each sector were purposively sampled. The selection criteria in these first stages were informed by the predominance of emerging market oriented crops (potato, beans and some fruits like tree tomato and passion fruits), the existence of high level of food insecurity as indicated by Hjelm *et al*., (2016). The existence of rural non-farm employment opportunities especially in the sector of trade, mining and tourism and the proximity to the Rwandan borders with DRC and Uganda as an opportunity to embark on non-traditional regional trade were also considered in the purposive choice of the province and

districts. In the fourth stage, two villages from each cell were systematically selected. During field visits, lists of the households from each village have been collected from the village leaders' office and smallholder households that mainly depend on self-employment in farming were identified. A total number of 1635 households were reported by the village leaders as being dependent to self-employment in farming but also having mainly involved women. These women could be either having husbands or not. This number was considered as the population from which the sampled households were selected. The simple random sampling method was applied for the selection of the sampled households for this study.

3.2.2. Sample size determination

The described steps of sampling were done with a target to identify the population for this specific study. In the literature, two formulae are commonly used for sample size determination namely the formula of by Cochran (1977) and the one provided by Yamane (1967). According to the tests done by Sarma and Hazarika (2012), these formulae lead to almost the sample though the former tend to give smaller samples compared to the second. In addition, the formula by Cochrane for finite population like in this study is calculated in two steps while straightforward with the formula by Yamane. Therefore, the identification of the sample size was determined using the formula by Yamane (1967):

$$\mathbf{n} = \frac{\mathbf{N}}{(\mathbf{1}+\mathbf{Ne^2})} \quad \text{.....Equation 8}$$

Where N= total population in the study area (13690 households in which women are involved as self-employed in farming) and e = level of precision (e=0.05 for this study). From the calculations, a sample size of 389 households was obtained as the minimum number of households to be used in this study.

Among the total number of the households, 7426 households were bean farmers (making 54% of the total population) and 6264 (46% of the total population) were mainly in potato production. In order to get the sample from each of these crops, proportional sampling method was applied in a way that among the total sample of 389 households, 46% were randomly selected from the potato producers and 54% was randomly selected from the bean producing households. This led to 178 households and 211 households for potato and bean crop, respectively. Finally, based on the location of the potato and bean producers, a proportion sampling gave the total of 89 and 122

households of bean producers from Gakenke and Burera districts respectively. For potato crop, 102 and 76 households were sampled from Burera and Musanze districts, respectively.

Regarding the qualitative data, the study followed a purposive sampling among the households that reported to have participated in output market. For this 4 and 3 focus group discussions were conducted respectively with women and men from the sampled households. Each of the FGDs counted 7 to 10 people each. The number and the composition of the groups was considered following Finch and Lewis (2003) who specified that homogeneity of the discussants and the number between six and eight would be appropriate to understand how people think about a specific topic.

3.3. Data collection techniques

A structured questionnaire was used to capture the information on households and personal socio-economic and institutional characteristics, their status of market participation, households' employment creation and finally, the households' food security status using the food access questionnaire. In order to understand the needs and experiences of women in the transformation to market oriented farming, all the information were collected in details on both spouses (in dual-headed) or the household head (in household headed by a woman). This was done through individual interviews with household heads or their spouses but qualitative information were also gathered through the FGDs. Quantitative data collection was done using Tablets with SurveyCTO software application. For the FGDs, a checklist of questions on marketing channels, supporting organisations, participation of women and men in production and commercialisation was used. Then the discussions were simultaneously recorded to better capture all the information.

3.4. Data Analysis

The analysis was done using MAXQDA 12 and Stata 14 respectively for qualitative and quantitative data. In qualitative analysis, the recorded discussions were first transcribed, then translated to English and transferred to the software for thematic analysis. For the quantitative analysis, descriptive statistics and econometric models were estimated according to the objectives of this study as detailed in the next sub-sections.

3.4.1. Objective One

The first objective was to examine the level of smallholder households and women farmers' participation in bean and potato marketing system as they progress towards market oriented production. This study first followed the framework by Layton (2007) and Cadilhon *et al*. (2003)

for the better understanding of the marketing system first. The framework starts with setting the system boundaries. This was done through identification of the element of interest among the four dimensions of marketing systems. These are the economic and social structure of the marketing system linkages, the other systems (parallel) if they exist, the components of the systems to analyse and the systems' environment. In the economic and social structure component, the individual, entities or groups of interest are identified and the primary system to analyse is specified (Layton, 2007). In this study, the primary system was the exchanges and flow of agricultural products, leading to a particular level of commercialisation of bean and potato in the research area. The secondary system includes the possible exchanges of services such as transport, credit or knowledge which exist between the stakeholders, facilitating the flow of the products.

The study assumes that the parallel systems do not exist, given the context of the research area. It focused on the stakeholders and their roles in the systems. Concerning the environment, Cadilhon *et al*. (2003) and Layton (2011) pointed out that, the existence of infrastructure and institutions that may have an influence on the system, should be considered. This study considered the government strategies (formal institution) related to agricultural commercialisation as enabling environment. Furthermore, it probed on the constraints and opportunities created by the local physical infrastructures and the institutions. Among the physical infrastructures the availability of good roads, physical market, and the access to resources such as land were considered. Concerning the institutions, the study mainly looked at the existing actors that are getting involved in the transformation toward market oriented agriculture while analysing the extent at which smallholder households interact with them. The interaction between women and the other actors of the system is particularly investigated and the level of women's participation in the marketing system was evaluated. The studied elements of the marketing systems are summarized in Appendix1.

Regarding the analysis, Layton (2007) distinguished two categories of approach to conduct marketing systems analysis. The descriptive approach of the existing systems which is based on detailed descriptive data and the analytical approach generally using mathematical modelling. This study falls in the former category, attempting to first map the emerging marketing system for two major crops in the study area. The information on the different elements were collected using desk research, individual interviews of the stakeholders and Focus Group Discussions with the smallholder farmers. The qualitative data was analysed using content analysis and thematic analysis. These are the common methods used in the qualitative descriptive studies (Vaismoradi

et al., 2013). Qualitative content analysis is the most appropriate method to analyse text data (Elo & Kyngäs, 2008) and was used to analyse the relevant governmental documents by coding the key words related to marketing systems. The thematic analysis was mainly used on the data from FGDs, by describing and interpreting the specific themes from the transcriptions. The detailed difference between the two approaches is given by Vaismoradi *et al*., (2013). The steps of qualitative data analysis are summarized in Table 1 as adapted from Braun and Clarke (2006) and Elo *et al*. (2014).

Table 1: Steps in qualitative analysis

Step	**Activities**	**Specific details to this study**
Preparation	-Decide on methods of data collection, sampling strategy and unit of analysis	-Focus Group discussions, desk research -Purposive selection of men and women farmers, data collection. -Purposive sampling of the government documents, review.
Transcription	-Transcribe the data and check against the audio for accuracy	-Data has been transcribed and translated from Kinyarwanda to English
Coding	-Go through the text and code the themes, check the themes against each other and compare with the original text.	-The coding has been done in MAXQDA 12.
Analysis	-Interpret the data, give them sense avoid describing only	The data are interpreted and explained in the Chapter 4
Reporting	-Systematically and logically report the results. -Use scientific language to convey the results.	The results are discussed in the Chapter 4.

3.4.2. Objective Two

The second objective was to determine the household and women's characteristics that affect smallholder households' participation in bean and potato output market. This study considered output market participation as a two-steps process in which the household first has to decide whether to participate and then the extent at which it should participate. These steps can be influenced by different factors (Martey, 2014; Musah *et al*., 2014). In the first step, the decision to participate was captured by whether the household has sold a certain proportion of the agricultural production or not. In the second step, the study used the household commercialisation index (HCI) by Strasberg *et al*.(1999) as a measure of the extent at which the household has participated to the market. This index has been used by Bekele *et al*.,(2010) and Carletto, Corral, and Guelfi (2017) in their respective studies on agricultural commercialisation in Ethiopia and in three countries namely Tanzania, Uganda and Malawi. The index is given by the formula:

$$\mathrm{HCI}_k = \frac{\sum_{i=1}^{n} S_{ki}}{\sum_{i=1}^{n} Q_{ki}} * 100,\ 0 \leq \mathrm{HCI}_k \leq 100 \quad \text{.....Equation 9}$$

Where, HCI_k is the market participation index of the household cultivating k crops during a specific year. S_{ki} is the gross value of k crops sales and Q_{ki} is the gross value of k crops produced. With this index, the farm household's commercialisation level is conceptualised as a continuum that ranges from **0** when then the household is in pure subsistence production and **100** when it is completely commercialised (Carletto *et al*., 2017). A household is considered to be market oriented when its HCI is equal or more than 50% (Bekele *et al*., 2010).

In the estimation of the factor influencing the extent of market participation, a Double-Hurdle model (DH), Heckman or a Tobit model could be used. The choice of one of them depends on the study's assumptions. Starting with the Tobit model, the literature indicate that it was developed by Tobin in 1958 as an extension of the Probit model (Gujarati, 2004). It is used in regression where dependents variables are limited above or/and below a specific threshold. Depending to research objectives, the threshold may be any number and the model fits well in the case where the value of the outcome is censored between 0 and 1. This is for instance the case where a researcher seeks to identify the determinants of households' expenses on a specific good (e.g. house renting). The individuals who spent nothing on the rent will have no data under the variable "housing expense" while the data is available for those who spent paid house rent. The dilemma is that both categories of individuals are in the same sample and OLS cannot be used to estimate

the model of interest (Gujarati, 2004). In the Tobit model, a latent variable Y_i* is used to relate with the dependent variable Y_i (i.e. housing expenses) as illustrated below:

$$Y_i = \begin{cases} Y_i^*, & Y_i^* > 0 \\ 0, & Y_i^* \leq 0 \end{cases} \quad \text{..... Equation 10}$$

and $$Y_i = \begin{cases} 0, & Y_i^* \leq 0 \\ Y_i^*, & 0 < Y_i^* \leq 1 \\ 1, & Y_i^* > 1 \end{cases} \quad \text{.....Equation11}$$

Where the Y_i^* is a function of the explanatory variables X_i in a one-limit Tobit model (Equation 10) and in two-limit Tobit model (Equation 11). It was observed that the two-limit model is very common in technology adoption studies for the estimation of the likelihood to adoption and the intensity of adoption (Adesina & Zinnah, 1993; Akinola *et al*., 2010; Idrisa *et al*, 2012).

In studies related to agricultural output market participation , Tobit models have been also applied with HCI or volume to sell as a dependent variable (Adeoti *et al*, 2014; Masinde *et al*, 2015). Despite the popularity of Tobit, the model has a limitation of using the same parameters (same process) to determine the probability of the dependent variable (Burke, 2009; Lin & Schmidt, 1984). In other words, the set of explanatory variables is the same for market participation and the level of participation as the decision to sell and the decision on the quantity to sell are assumed to be simultaneous. However in a study conducted in Kenya and Ethiopia, Bellemare and Barrett (2006) specified that the two decisions are sequentially made. Thus they may have separate determinants and studies which consider these decisions to sequential would find Tobit model too restrictive. The present research looks at market participation as being done in sequences. In fact, the two decisions are likely to be influenced by different factors, given the conditions of smallholders in Rwanda. For example the factor like output price which is mostly volatile and determined at market place (i.e. at selling time) cannot influence the farmers' decision to sell. However, this factor has been found highly affecting the mount sold (Musah *et al*., 2014; Omiti *et al*., 2009). The same trend would be observed for the other institutional factors like distance to the market and membership to cooperative.

Another model commonly used in market participation analysis is the standard Heckman sample selection model which has been developed by Heckman (1976). The model was proposed in the case of correcting the selection bias caused by the aforementioned missing dependent variable (outcome variable) in a large random sample (Heckman, 1976, 1979). The common

illustration on which the development of this model was based is the labour force participation study where the comparison of wages for women workers and the non-workers was leading to bias. The non-random sub-sample of working women was not allowing to know the information on the other group of women (Bushway *et al*.,2007). It is a two-step model and it relaxes the restriction in Tobit by allowing the estimation of market participation and its intensity (Sebatta *et al*, 2014).

The first step in this model uses a Probit regression, estimating P(Y=1|X*i*) while a correction factor from the first step is inserted in the second regression of interest for an Ordinary Least Square (OLS) estimation (Bushway *et al*., 2007; Gujarati, 2004). The model was widely used in market participation analyses as for instance in Abeykoon *et al*. (2013), Kuma *et al*. (2014), Sebatta *et al*.(2014) and Sigei *et al*. (2013). Its capacity of considering the two decisions in separate regressions fits this study. However, the model is designed for the situation where zeros are unobserved values or missing values (Reyes *et al*., 2012). In the data where zeros represent farmers' optimal choice, Reyes *et al*.(2012) recommended to use the Tobit and the Double-Hurdle models. However, as the former model was found less appropriate, this study chose to use the Double-hurdle model.

The Double-Hurdle (DH) or two-tiered model was proposed in 1971 by Cragg and it allows for the possibility of having different set of factors influencing the market participation and its level (Eakins, 2014). With DH model, a farmer is assumed to pass into two distinct hurdles in the process of output market participation. In the first hurdle, a Probit regression is estimated to determine the factors affecting market participation (decision to sell). In the second, a truncated normal regression model (Tobit) is used over the non-zero value observations (for those who sold), to identify the determinants of the level of participation (Burke, 2009; Reyes *et al*., 2012). This model, being more flexible than Heckman and Tobit models, was used in various market participation analyses (Martey, 2014; Musah *et al*., 2014; Weyessa, 2014). The present study will use the same model with the below general form following Newman *et al*. (2003) and Weyessa (2014). Its general form is given by the following:

$y_{i1}^{*} = w_i\alpha + v_i \quad First\ step\ (or\ hurdle\ )$.....Equation 12

$y_{i2}^{*} = x_i\beta + u_i \quad Second\ step\ (hurdle)$.....Equation 13

For: $y_i = x_i\beta + u_i \quad if\ y_{i1}^{*} > 0 \quad and \quad y_{i2}^{*} > 0$ .....Equation 14

Where: y_{i1}^{*} and y_{i2}^{*} are respectively the latent dependent variables representing household decision to participate and the extent of participation, y_i is the observed dependent variable, w_i and x_i are respectively the sets of independent variables explaining the decision to participate and the extent of participation and v_i and u_i are independent error terms, assumed to be normally distributed.

According to Newman *et al*. (2003), there is no specific theory on the independent variables to be included in the DH models. However, the authors specified that the sets of these variables should be different in each model while avoiding economic factors such as income in the first equation. The latter is assumed to be more linked with social and psychological factors (Eakins, 2014 citing Pudney,1982). It was noted that some studies included assets in the first and the second model (Reyes *et al*., 2012). Guided by this literature and the conceptual framework, the specified model was:

Hurdle 1 (Participation to output market):

$$Y_{1i} = \beta_0 + \beta_1 Age_w + \beta_2 Education_w + \beta_3 Occupation_w + \beta_4 Headship_h + \beta_1 Maritalst_w + \beta_5 HHsize_h + \beta_6 Land_h + \beta_{15} ImprovedIn_h + \beta_7 Distmarket_h + \beta_8 Distroad_h + \beta_9 Location_h + \beta_{10} Extension_h + \beta_{11} Ag\ training_w + \beta_{12} Memgroups_w + \beta_{13}\ AgDecision_w + + \beta_{16} ResponsCrop_h + V_i$$

Hurdle 2 (Extent of participation):

$$Y_{2i} = \beta_0 + \beta_1 Age_w + \beta_2 Education_w + \beta_3 Occupation_h + \beta_4 HHsize_h + \beta_5 Land_h + \beta_6 Distmarket_h + \beta_7 Distroad_h + \beta_8 Location_h + \beta_9 Credit_h + \beta_{10} MarkPrice_h + \beta_{11} CommuAsset_h + \beta_{12} TransAsset_h + \beta_{13} Livest_h + \beta_{14} AgIncome_h + \beta_{15} ResponsCrop_h + \beta_{16}\ OutDecision_w + U_i$$

The subscripts *w* and *h* respectively show the independent variables specific to women (household head or spouse) and households. The description of independent variables and their expected signs are given in Table 2 and Table 3.

Table 2. Description of variables in the first regression (Participation to output market)

Independent variables	**Description**	**Expected sign**
Women and Household characteristics		
Age_w	Age of woman (continuous)	+
$Headship_h$	Headship of household (1= Headed by a woman, 0=Headed by a man)	+
$Education_w$	Years of schooling of woman (continuous)	+
$Occupation_w$	Main occupation of woman (0 if self-employed in farming,1 otherwise)	-
$Maritalst_w$	Dummy =1 if the woman is/was in official marriage, 0=if not	+
$HHsize_h$	Household size (continuous)	-
Assets and improved inputs use		
$Land_h$	Agricultural landholding in hectare (continuous)	+
$ImprovedIn_h$	Dummy=1 if the household has used any of improved inputs of interest (Seed, fertilisers or pesticides), 0 otherwise	+
Decisions on agricultural technologies		
$AgDecision_w$	The extent at which the woman participate in agricultural technology use. Ordinal, with 1=No input (reference) 2=Input in very few decisions 3=Input in some decisions 4=Input in most of the decisions 5=Into all the decisions	+
$ResponsCrop_h$	The person perceived to be responsible of the crop. Categorical, with: 1=Adult man(spouse of elder son):reference 2= Woman alone 3= Woman with other members	+/-

Table2. Description of variables in the first regression - Continuation

Independent variables	**Description**	**Expected sign**
Institutions and access		
$Agtraining_w$	Having attended an agricultural/agribusiness oriented training (1 if yes, 0 otherwise)	+
$Extension_h$	Number of visits by extension officer (continuous)	
$Memgroups_w$	Woman being a member of a group. Dummy 1= yes, 0 otherwise	
$Distroad_h$	Distance to the nearest good road (categorical)	
$Distmarket_h$	Distance to the market town (categorical)	
$Distroad_h$	Time to the nearest usable road. Dummy 0=if the household members use less than 60 min walking to all weather road, 1 when they use more time	-
$Distmarket_h$	Time to the nearest market. Dummy 0=if the household members use less than 60 min walking to market, 1 when they use more time	-
$Border_h$	Time to Cyanika Border (with Uganda). Dummy 0=if the household members use less than 60 min in a public transport to reach the border, 1 when they use more time	+
$Location_h$	Geographical location with reference to district (1=Burera (reference),2=Gakenke,3=Musanze)	+/-

Table 3. Description of variables in the second regression (Extent of household' participation)

Independent variables	**Description**	**Expected sign**
Women and Household characteristics		
Age_w	Age of woman (continuous)	+
$Headship_h$	Headship of household (1= Headed by a woman, 0=Headed by a man)	+
$Education_w$	Years of schooling of woman (continuous)	+
$Occupation_w$	Main occupation of woman (0 if self-employed in farming,1 otherwise)	-
$Maritalst_w$	Dummy =1 if the woman is/was in official marriage, 0=if not	+
$HHsize_h$	Household size (continuous)	-
Assets and improved inputs use		
$Land_h$	Agricultural landholding in hectare (continuous)	+
$TransAsset_h$	Number of transport assets including bicycle, motorbike and cars (continuous)	+
$CommuAsset_h$	Whether the woman farmer has a mobile phone. Dummy=1 if yes ,0 otherwise	+
$Livest_h$	Household has a livestock. Dummy =1 if yes, 0 otherwise	
Decisions on agricultural output		
$OutDecision_w$	The extent at which the woman participate in decision over the quantity to be sold. Ordinal, with 1=No input (reference) 2=Input in very few decisions 3=Input in some decisions 4=Input in most of the decisions 5=Into all the decisions	+

Table 3. Description of variables in the second regression - Continuation

Independent variables	Description	Expected sign
$ResponsCrop_h$	The person perceived to be responsible of the crop. Categorical, with: 1=Adult man(spouse of elder son):reference 2= Woman alone 3= Woman with other members	+/-
Institutions and access		
$Agtraining_w$	Having attended an agricultural/agribusiness oriented training (1 if yes, 0 otherwise)	+
$MarkPrice_h$	Market price of the output sold per Kg(continuous)	+
$Extension_h$	Number of visits by extension officer (continuous)	
$Memgroups_w$	Woman being a member of a group. Dummy 1= yes, 0 otherwise	
$Distroad_h$	Time to the nearest usable road. Dummy 0=if the household members use less than 60 min walking to all weather road, 1 when they use more time	-
$Distmarket_h$	Time to the nearest market. Dummy 0=if the household members use less than 60 min walking to market, 1 when they use more time	-
$Border_h$	Time to Cyanika Border (with Uganda). Dummy 0=if the household members use less than 60 min in a public transport to reach the border, 1 when they use more time	-

3.4.3. Objective Three

The third objective was to determine the influence of output market participation on food access among beans and potato farming households. This study used the Household Food Insecurity Access Scale (HFIAS) as one of the current common indicators of food insecurity. Seven indicators which are commonly used have been classified by Maxwell, Vaitla and Coates (2014)

and HFIAS was described as one of the best known and used in experiential measures of food access. This measure was particularly chosen in this study for it allows to capture the psychological dimension of food insecurity experience of respondents. This was crucial for the context of Rwanda where, some criticisms that market orientation can lead to increased vulnerability to food insecurity have been raised (Ansoms & Rostagno, 2012b). Actually in some cases where farmers were reluctant to embark in cash crop production, one may understand that they were risk-averse individuals who feared a negative effect that may be caused by this new production system on their household food security (MINAGRI, 2013; Ansoms, 2010). Indeed, the decision of farm households to increase their market participation is linked to the level of their satisfaction in terms of food access. So in this context, measuring food access with HFIAS was the good possible way to capture personal evaluation of their food security as well as the psychological dimension of this status while allowing for to quantify its relationship with market participation.

The HFIAS approach uses nine questions (items) designed to help in the classification of households based on three domains linked to inadequate access to food (experience of food insecurity). These are the uncertainty or worries that food would not be sufficient, insufficient quantity of food leading to reduction of food intake and insufficient food quality which includes preferences and acceptability (Vink, 2012; Coates *et al*., 2006). The questions ask whether the respondent worried about food insecurity and/or had a particular behaviour related to insufficient food quantity and quality in the last 30 days from the day of interview. Each of the nine questions have four options of answers ranked from 0 to 3 (never to often), representing the frequencies by which the household has experienced a particular indicator of inadequate access. From the answer given to each question, a variable which is the HFIAS score (S_i) was calculated and the higher the value of S_i, the more food insecure (access) is the household (Coates *et al*., 2006). The score became a categorical variable that was transformed to generate four groups of food secure (1), mildly food insecure (2), moderately food insecure (3), and severely food insecure (4). In order to facilitate the interpretation, the categories were recorded in an inversed order (food secure (4), mildly food insecure (3), moderately food insecure (2) and severely food insecure households (1). The measure of the food access categories is an ordinal outcome since it is categorical and ordered. Therefore, ordered Logit models would be the appropriate models to estimate the factors that have an influence in household's perceptions of household food access.

The probability of a household food security being either one of the four categories was estimated as a linear function of a vector of covariates and a set of cut-offs. Hence, the probability of observing the i^{th} food access status within a range of cut-offs given as:

$$\Pr(\text{outcome}_j = i) = \Pr(k_{i-1} < \beta_1 X_{1j} + \beta_2 X_{2j} + \beta_3 X_{3j} + ... + \beta_k X_{kj} + \varepsilon_j \leq k_i) \quad \text{.....Equation 15}$$

where $\beta_1, \beta_2 \beta_3, \ldots, \beta_k$ are coefficients associated with independent variables $X_1, X_1, X_3, \ldots, X_\kappa$, $k_1, k_2, k_3, ..., k_{\kappa-1}$ are cutpoints with k being the number of possible outcomes, and μ_j is the disturbance term that is assumed to take a logistic distribution.

Ordinarily, equation 15 would be econometrically estimated using the standard ordered Logit model. However, the standard ordered Logit model is restrictive because of the parallel-lines assumption. The standard ordered Logit assumes equal parameterisation on the model, meaning that coefficient (β) estimates are the same across j categories. The violation of the parallel-lines assumption is common because one or more parameter estimates may differ across j categories of an ordered outcome variable (Williams, 2016). To overcome the limitation of the standard ordered Logit model, this study applied generalized ordered Logit model to estimate the effect of bean and potato commercialisation on household food security. Following Williams (2006), the general form of generalized ordered Logit model is written as:

$$P(Y_i > j) = f(\mathrm{X}\beta_j) = \frac{\exp(\alpha_j + X_i\beta_j)}{1 + \{\exp(\alpha_j + X_i\beta_j)\}}, \qquad j = 1, 2, ..., M-1 \quad \text{.....Equation 16}$$

where M is the number of categories of food security. The probabilities that Y will take on a value ranging between 1 and 4, with four being the maximum number of food access security are given as follows:

$$P(Y_i = 1) = 1 - f(X_i\beta_1) \quad \text{.....Equation 17}$$

$$P(Y_i = j) = f(X_i\beta_{1-1}) - f(X_i\beta_j) \qquad j = 2, ..., M-1 \quad \text{.....Equation 18}$$

$$P(Y_i = M) = f(X_i\beta_{M-1}) \quad \text{.....Equation 19}$$

β_S are the vectors of the explanatory variables while i and k respectively denote the individual household and the number of categories of food access status. X_s are explanatory variables

including women and households' characteristics with a particular focus on household' participation in output market. Table 4 present the explanatory variables included in the (Generalized) Ordered Logit models. The specified form is:

$P(Y_i)=\beta_0 + \beta_1 Age_w + \beta_2 Education_w + \beta_3 Occupation_w + \beta_4 Headship_h + \beta_5 MarketPrice_h + \beta_6 HHsize_h + \beta_7 Land_h + \beta_8 Saving_h + \beta_9 DistMarket_h + \beta_{10} ClimateHazard_h + \beta_{11} Shockill_h + \beta_{12} Income_h + \beta_{13} DecisInc_h + \beta_{14} DecisQuant_h$

Table 4 . Description of the explanatory variable in the ordered Logit models

Independent variables	**Description**	**Expected sign**
Age_w	Age of woman (continuous)	+
$Headship_h$	Headship of household (1= Headed by a woman, 0=Headed by a man)	+
$Education_w$	Years of schooling of woman (continuous)	+
$Occupation_w$	Main occupation of woman (0 if self-employed in farming,1 otherwise)	-
$HHsize_h$	Household size (continuous)	-
$Land_h$	Agricultural landholding in hectare (continuous)	+
$MarkPrice_h$	Market price of the output sold per Kg(continuous)	+
$Saving_h$	Being part of saving group (1=Yes,0=Otherwise)	+
$Distmarket_h$	Time to the nearest market. Dummy 0=if the household members use less than 60 min walking to market, 1 when they use more time	-
$Income_h$	Total income in the household	
$AgDecision_w$	The extent at which the woman participate in agricultural technology use. Ordinal, with 1=No input 2=Input in very few decisions…. 5=Input in most/all decisions	+

Table 4. Description of the explanatory variable in the ordered Logit models - Continuation

Independent variables	Description	Expected sign
$IncoDecision_w$	The extent at which the woman participate in income decision. Ordinal, with 1=No input 2=Input in very few decisions 3=Input in some decisions 4=Input in most of the decisions 5=Into all the decisions	+
$QuantDecision_w$	The extent at which the woman participate in the quantity to sell. Ordinal, with 1=No input 2=Input in very few decisions 3=Input in some decisions 4=Input in most of the decisions 5=Into all the decisions	+
ClimatHazard	Whether the household has experienced a shock related to climate (1=Yes, 0 Otherwise)	-
ShockIll	Whether the household has experienced a shock related to illness (1=Yes, 0 Otherwise)	-

3.4.4. Objective Four

The last objective of this study was to evaluate the effect of output market participation on farm employment among bean and potato farming households. Market participation is considered within the realms of potential market participants making decisions that are of their own best interests. Participation in the output markets and the degree of participation are decisions of heterogeneous market participants, aiming to optimise specific outcomes. Both observed and unobserved characteristics influence market participation, thereby making participation preferred than other options. However, participation in output markets is not randomly assigned to households, implying that some households self-select themselves into market participation. Also market participation takes place in presence of constraints. Thus, as suggested by Imbens and

Wooldridge (2009), a research design that accounts for self-selection needs to be applied in estimating the impact of market participation on employment creation within farm households.

In the context of the current study, assignment into market participating and non-participating groups is non-random. This implies that at any particular time, a household is either participating in the market or not. In addition, it means that counterfactual outcomes are unobservable. Therefore, it is of great importance to apply econometric techniques that identify non-market participating group that is reasonably as well as statistically similar to the participating group of households. This helps in constructing the missing counterfactual which in this particular study, refers to what employment outcomes would have been for market participants had they not participated in the output markets.

Propensity score matching (PSM) is a widely used estimator in assessment of treatment effects on household livelihood outcomes (Imbens, 2015). PSM overcomes selection bias due to non-random selection into intervention by creating a comparison group of non-participants to which outcomes of interventions for the participating group are compared. The comparison group consists of individuals or households with similar pre-intervention characteristics to the participating group characteristics. PSM controls for sample selection bias by handling the unobservable characteristics and controlling for the observable characteristics and balancing of independent variables across participants and non-participants.

Following Kebebe (2017), the study defined two employment outcomes and market participation indicator. The employment outcomes are Y_{1i} and Y_{0i}, where Y_{1i} represents on-farm employment outcome for household i that participated in output markets and Y_{0i} represents on-farm employment outcome for household i that did not participate in the output markets. On the other hand, $T_i 0$ denotes non-participation in the market. A household can only be in one state of intervention at any particular time. Thus, the observation equation is given as:

$$Y_i = T_i Y_{1i} + (1 - T_i) Y_{0i} \quad \text{.....Equation 20}$$

where Y_i is the observed on-farm employment outcome for household i. The observed on-farm employment outcome is observed for the participating household while the non-participating household remains counterfactual. In particular, non-participation on-farm outcome is observed for non-participating household while the market participation outcome remains a counterfactual.

Then the difference between market participation on-farm employment outcome and non-market participation on-farm employment outcome defines the unobserved treatment effect for each household as given by equation 21.

$$\delta_i = Y_{1i} - Y_{0i} \quad \text{.....Equation 21}$$

The average of δ_i is selected depending on the research question. The study focused on two treatment averages; average treatment effect (ATE) and average treatment effect on the treated (ATET). The ATE is defined as the difference between the average outcome variable of the market participating households and non-market participating households. That is, difference in average on-farm employment between market participating households and non-market participating households. In other words, the ATE is the average causal effect and is given as:

$$ATE = E[Y_{1i} - Y_{0i}] \quad \text{.....Equation 22}$$

The ATET, which is average difference in the outcome variable between households participating and their counterfactuals, is specified as follows:

$$ATET = E[Y_1 - Y_0 \mid T = 1] \quad \text{.....Equation 23}$$

The PSM is founded on observed variable assumption which implies that observed heterogeneity accounts for the self-selection into intervention and control groups. This makes PSM to be possibly sensitive to bias in a situation where the state of treatments or outcome model is affected by unobservable confounders (Imbens, 2015). In addition, according to Rosenbaum (2002) and DiPrete and Gangl (2004), PSM performs poorly with small samples as it is the case with the present study. Cattaneo (2010) suggested checking the robustness of PSM estimates using double-robust estimators. The Inverse Probability Weighting Estimator with Regression Adjustment (IPWRA) is one of the double-robust estimators which gives consistent treatment effects when either the treatment model or outcome model is misspecified. The IPRWA uses weighted regression coefficients to estimate ATE and ATET, giving additional opportunity for achieving correct specification.

The IPWRA weights the treatment or the outcome measures by the inverse of the probability of the observation conditioned on a vector of covariates (x). The weighting is independent of the state of treatment. Following Hernán and Robins (2019), the propensity score for the IPWRA process is denominated as:

$$p(x) = P(T = 1 \mid X = x)$$ ……...Equation 24

The weight for market participating households is given by:

$$w(x) = \frac{1}{p(x)}$$ ……..…….…….....Equation 25

The weight for non-market participating households is given by: $w(x) = \frac{1}{1 - p(x)}$ …..Equation 26

The propensity score for each individual is unknown because of non-random assignment into the intervention and control groups. However, the state of treatment and the measured covariates can be measured for each individual. Therefore, a logistic regression model, besides estimating probability of treatment, can also be used to generate propensity scores (Hernán & Robins, 2019).

The causal effect in the presence of confounders can be estimated by inverse probability (IP) weighting of the original treatment or outcome estimator which is specified as:

$$\begin{aligned}\hat{\tau}^{IP} &= \frac{1}{n_T}\sum_{i:T=1_i}\frac{Y_i}{\hat{p}(X_i)} - \frac{1}{n_C}\sum_{i:T_i=0}\frac{Y_i}{1-\hat{p}(X_i)} \\ &= \frac{1}{n}\sum_{i}^{n}\frac{T_i Y_i}{\hat{p}(X_i)} - \frac{1}{n}\sum_{i}^{n}\frac{(1-T_i)Y_i}{1-\hat{p}(X_i)}\end{aligned}$$ ……..……...Equation 27

where $\hat{p}(x)$ is a logistic regression model for estimating propensity scores. Equation 28 and 29 show that the quantity given in equation 27 is unbiased estimator for equations 22 and 23 (Hernán & Robins, 2019).

$$E\left[\frac{YT}{P(X)}\right] = E[Y(1)]$$ ……..……...Equation 28

$$E\left[\frac{Y(1-T}{1-p(X)}\right] = E[Y(0)]$$ ……....Equation 29

For instance, equations 28 can be simplified as:

$$\begin{aligned}E\left[\frac{YT}{P(X)}\right] = E[Y(1)] &= E\left[E\left[\frac{YT}{p(X)}\middle| X\right]\right] \\ &= E\left[E\left[\frac{Y(1)T}{p(X)}\middle| X\right]\right] \\ &= E\left[\frac{E[Y(1) \mid X]\,E[T \mid X]}{p(X)}\right]\end{aligned}$$ ……Equation 30

$= E[E[Y(1) \mid X]]$

$= E[Y(1)]$

The same equality in equation 30 applies to equation 29.

Following Hernán and Robins (2019), the stabilized weight which corrects potentially large-weights for individuals with propensity score close to zero are given as follows for the market participating households:

$$w(x) = \frac{P(T=1)}{p(x)} = \frac{P(T=1)}{P(T=1 \mid X=x)} \quad \text{.....Equation 31}$$

The stabilised weight for non-market participating households is given by:

$$w(x) = \frac{1-P(T=1)}{1-p(x)} = \frac{1-P(T=1)}{1-P(T=1 \mid X=x)} \quad \text{.....Equation 32}$$

The set of explanatory variables for employment for those who participated and those who have not are given in Table 5.

Table 5. Description of covariates in the Logit models

Independent variables	**Description**	**Expected sign**
Employment model		
Age_w	Age of woman (continuous)	+
$Headship_h$	Headship of household (1= Headed by a woman, 0=Headed by a man)	+
$Education_w$	Years of schooling of woman (continuous)	+
$Occupation_w$	Main occupation of woman (0 if self-employed in farming,1 otherwise)	-
$HHsize_h$	Household size (continuous)	-
$Land_h$	Agricultural landholding in hectare (continuous)	+
$TransAsset_h$	Number of transport assets including bicycle, motorbike and cars (continuous)	+
$Credit_w$	(1 if accessed, 0 otherwise)	
$Income_h$	Total income in the household	
Age_w	Age of woman (continuous)	+
$Headship_h$	Headship of household (1= Headed by a woman, 0=Headed by a man)	+
$Education_w$	Years of schooling of woman (continuous)	+
$Occupation_w$	Main occupation of woman (0 if self-employed in farming,1 otherwise)	-
$HHsize_h$	Household size (continuous)	-
$Land_h$	Agricultural landholding in hectare (continuous)	+
$ImprovedIn_h$	Dummy=1 if the household has used any of improved inputs of interest (Seed, fertilisers or pesticides), 0 otherwise	+

Table 5. Description of covariates in the Logit models - Continuation

Independent variables	**Description**	**Expected sign**
Market participation model		
$AgDecision_w$	The extent at which the woman participate in agricultural technology use. Ordinal, with 1=No input 2=Input in very few decisions 3=Input in some decisions 4=Input in most of the decisions 5=Into all the decisions	+
$ResponsCrop_h$	The person perceived to be responsible of the crop. Categorical, with: 1=Adult man(spouse of elder son) 2= Woman alone 3= Woman with other members	+/-
$Agtraining_w$	Having attended an agricultural/agribusiness oriented training (1 if yes, 0 otherwise)	+
$Memgroups_w$	Woman being a member of a group. Dummy 1= yes, 0 otherwise	+
$Extension_h$	Number of visits by extension officer (continuous)	+
$Border_h$	Time to Cyanika Border (with Uganda). Dummy 0=if the household members use less than 60 min in a public transport to reach the border, 1 when they use more time	-

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1. Women farmers' characteristics

In the total sample, the average age of women farmers was 42.74 years, ranging between 20 years to 99 years old. The average age for bean producers was 43.27 years while for potato farmers was 42.10 years. The age of farmers is a considerable element in farm households' production ability. The age of a farmer can influence in the decision-making process where older people may be more experienced and therefore, make relatively informed decisions compared to the less experienced farmers implying that age can either have a negative or positive effect. This could allude to the fact that older farmers may not be open to new technologies and innovations hence, negatively affecting their production compared to younger ones. Moreover, in a system where farm households mostly depend on family labour, production reduces as farmers get older. Diametrically, older farmers may be more experienced in farming and wealthier (in terms of landholding, for example) which can positively affect their production and later their market participation.

Results in Table 6 show that when the households were disaggregated by crop, the age of women was not significantly different between those that participated in output markets and those who did not. However, when the combined sample was considered, differences in age were slightly significant (10% level). The positive sign of the t-value implies that the average age of the women in non-participating households is higher than that of women from participating households. So considering age, more households with older women did not participate compared to those with younger ones. The plausible explanation for this could be that younger women contribute more or provide quality labour that enables households to produce more compared to their counterparts.

Table 6. Age and education level of women farmers

	Beans			Potato			Combined		
Variable	Non-P	P	*t-value*	Non-P	P	*t-value*	Non-P	P	*t-value*
Mean Age (years)	44.04	41.8	1.03	44.5	41.5	1.05	44.2	41.6	1.64*
Mean Schooling years	2.3	2.9	-1.40*	1.3	3.4	-4.22***	2.1	3.3	-4.04***

*, ***, denote significance at 10% and 1% levels, respectively

In Table 6, results on the education level of women are presented. The results show that the number of schooling years of women farmers was higher among the households that participated in output markets. The difference was statistically stronger in the sample of potato farmers' households (1% level) as well as in the combined sample. The average years of formal education for women farmers was around 3 years. This means that in the combined sample, an average woman farmer has only completed her third year in primary school which is low.

The proportion of women farmers per category of education level is presented in Figure 3. Bean farmers had a higher percentage of women who had no formal education compared to potato producers (52.6% versus 40.5% of respondents). Additionally, in more potato farming households, women have attended some additional classes after primary while a good number had incomplete primary level (47.2 % versus 37.4 %). These results imply that women farmers have a low level of formal education where a significant percentage had no formal education. It would be difficult for these women to enter the market. Moreover, literature has shown that women with lower education have a lower position in intra-household decisions.

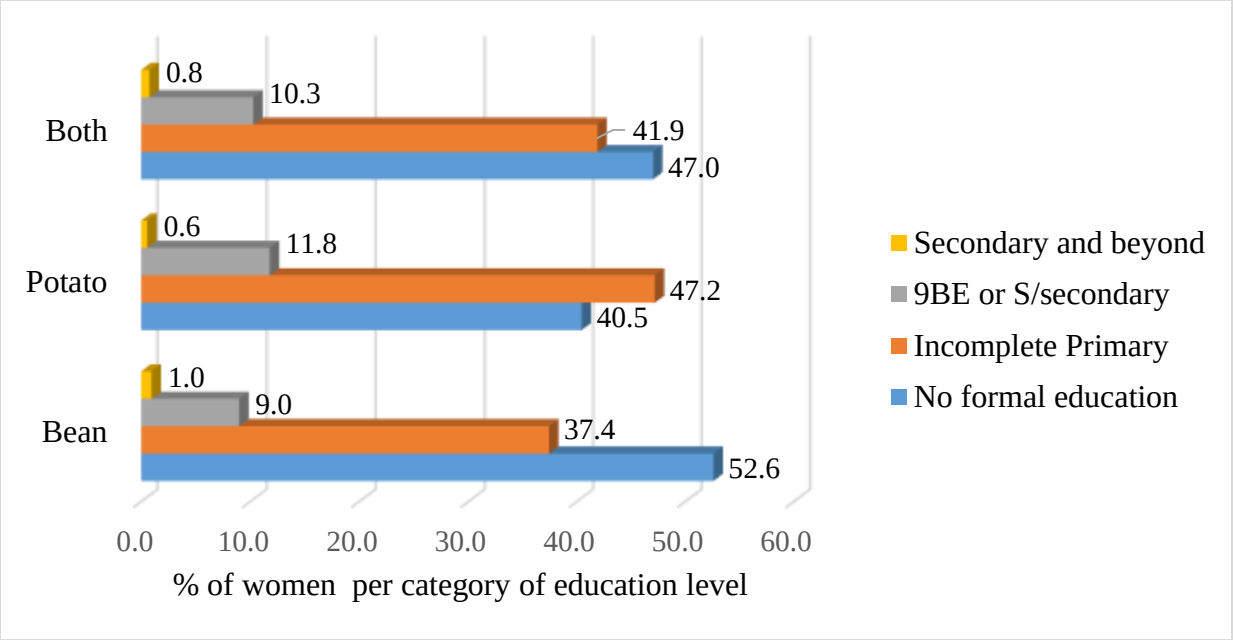

Figure 3: Education level of women farmers

In relation to marital status of the respondents, the majority of women were officially married which means they had civil and religious marriage as per the context of Rwanda. As displayed in Figure 4, the proportion of these women was 45%, around 43% and 44% in the bean, potato and combined sample respectively. The next group is made by those who only had civil marriage. They were around 27% in all the samples while those who were cohabiting were around 13%, 17% and 15% in the bean, potato and combined samples respectively. The widows were around 11% and the separated as well as single (never married) were the smallest categories grouping between approximately 1% and 2% of women farmers.

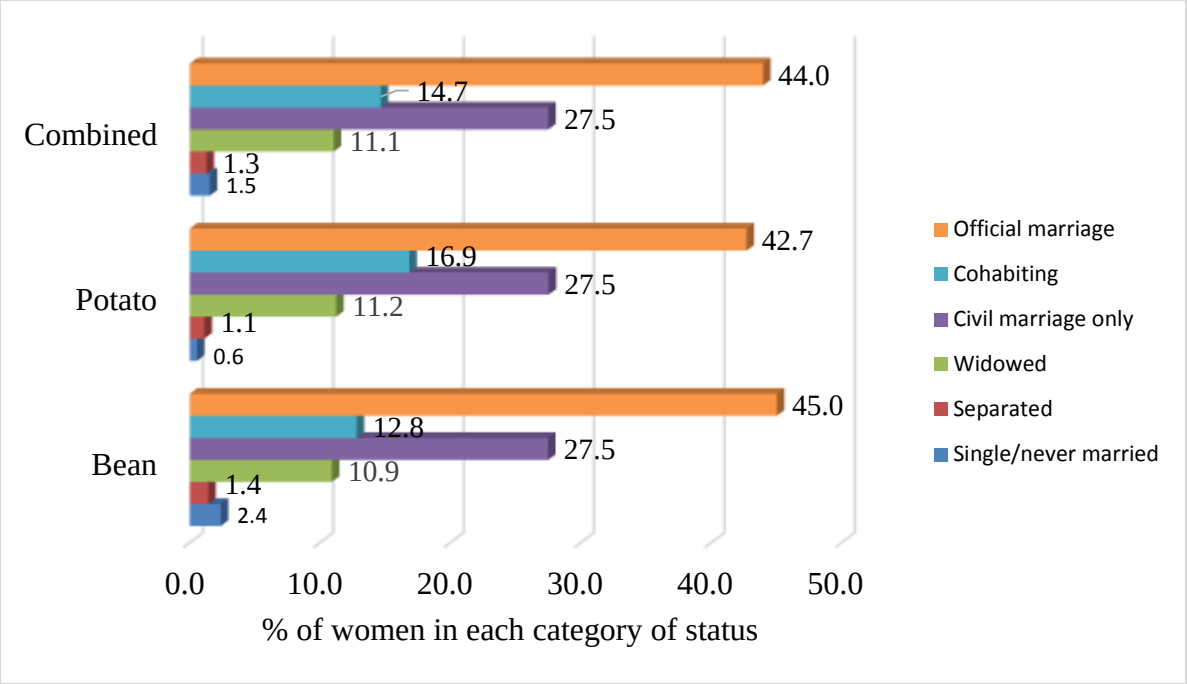

Figure 4: Marital status of women farmers

The results on the marital status of women farmers are particularly relevant in the context of this study since they may determine how women farmers use agricultural land either for production or for other purposes. In a nutshell, the use of particular assets like land, depend on the status of a woman in the household. According to Bayisenge (2018), a woman in an official or civil only marriage has equal rights as her husband on land. This may put her in a better position in terms of decision over land use compared to those who are only cohabiting without official rights on the land. The rights to land increase the bargaining power and autonomy of legally married women within their households (Daley *et al*., 2010). Talking about the latter category, Bayisenge *et al*. (2015), stated that the law permits these women to get the title only for the land that they have acquired independently. But this excludes the plots which were acquired with their husbands. Insecure land rights can have repercussions on agricultural productivity and output market participation in the long-run (Daley & Englert, 2010).

In this study, households' participation in output markets was compared based on women's legal right resulting from their marital status. As reported in Table 7, the comparison of participating and non-participating households revealed no significant difference in terms of women's status. However, a proportion test revealed that among those who participated, the percentage of households where women have legal rights was significantly higher. The reason for

this may not be the possible link between market participation and women's legal rights but rather the fact that the proportion of households with official and civil marriages were already considerable. In fact, with the land tenure reforms in the country, more couples have been encouraged to legalise their marriage which increased the number of women in official marriages. This was particularly due to the government-led campaigns to create awareness of the benefit of registered marriages for women (Daley *et al*., 2010). It is noteworthy that women from single-headed households were counted as having the legal rights on the land.

Table 7: Women's legal rights on land and participation to output market

	Bean		Potato		Combined	
	Non-P	P	Non-P	P	Non-P	P
Without legal rights (%)	28.1	26.4	28.6	30.1	28.2	28.8
With legal rights (%)	71.9	73.6	71.4	69.9	71.8	71.2

Chi-square test

Beans: Non Participated vs Participated: χ^2 = 0.0663

Potato: Non Participated vs Participated: χ^2 = 0.0302

Combined: Non Participated vs Participated: χ^2 = 0.0216

Proportion test within the Participated

Beans: prop (Without legal rights)-prop (With legal rights): *z* = -3.68***

Potato: prop (Without legal rights)-prop (With legal rights): *z* = - 4.44***

Combined: prop (Without legal rights)-prop (With legal rights): -5.79***

***, denotes significance 1% level

Besides the legal rights that were expected to play a role in how women participate in land use, their access to agricultural training and credit as well as their membership to a group in their area was analysed. Results showed that 47% of women from the studied households were members of groups while only 19% and 16% had accessed agricultural training and credit respectively. Findings showed that there was a significant association between access to training by women and output market participation in the output market at 1% level of significance. Among those who are members of a group, the proportion of market participant was significantly higher. Moreover, even

when a comparison was made within the group of those who had participated, it was explicit that the proportion of households with women who were members of a group was higher and the trend was the same for both crops as presented in Table 8.

Table 8: Women's access to training and groups

	Beans		Potato		Overall	
	Non-P	P	Non-P	P	Non-P	P
No training	69.1	30.9	20.9	79.1	47.8	52.2
Training	50.0	50.0	15.4	84.6	32.0	68.0
No group	82.4	17.6	40.6	59.4	69.4	30.6
Group	31.9	68.1	7.9	92.1	29.3	53.0

4.2. Household characteristics

Men headed households were the majority of the sampled households (86%) while 14% were under the headship of women. Approximately 54% and 46% of the farmers considered beans and potato as their main crops respectively with an average landholding of 0.4Ha and 0.6Ha for beans and potato production respectively. The t-test statistic indicated that the average land size for potato producers was statistically different from that of beans production at 1%. The possible explanation for this is that potato farming households could be having more income than beans farming households that is in turn invested in expanding their farms. Land is considered a critical resource enabling smallholder households to participate in output markets. With sufficient size of land, farm households can easily adopt improved technologies or access to financial services which generally allow them to increase their production for the market (Olwande *et al*., 2015). Thus, participation in markets is expected to be higher among households with larger agricultural land. Results indicated that, 55% of the population participated in output market, with around 66% and 34%, respectively, being potato and bean farming households.

Table 9 shows results from the comparison of household size and land size between farmers who did not participate in output markets (Non-P) and those who have participated (P). Between the two groups, land was significantly different for both crops and in the pooled sample. The farm households who have participated in the market had bigger land size. This is consistent with what various scholars highlighted regarding the importance of land size in smallholder market access and participation (Barrett, 2008; Donovan & Poole, 2014).

Table 9: Land and household size by households' market participation status

	Beans			Potato			Combined		
	Non-P	P	*t-value*	Non-P	P	*t-value*	Non-P	P	*t-value*
Mean Land size (Ha)	0.31	0.56	-3.5***	0.30	0.67	-2.72***	0.31	0.63	-5.21***
Mean household size(numbers)	5.63	5.11	1.55*	5.66	5.2	1.11	5.63	5.17	2.03**

*, **, ***, denote significance at 10%, 5%, and 1% levels, respectively

Since land expansion is a problem for most smallholder farmers, investment in land productivity and use of improved inputs are usually recommended. Wiggins (2014), noted that in Africa, the increase in agricultural output that comes from land expansion has been modest in the last decade. Land productivity, resulting from soil fertility measures and technological change at individual farm households has rather played a considerable role (Wiggins, 2014). In Rwanda, intensification is the core part of the transformation to market-oriented agriculture. Results of this study show a significant difference (at 1% level) in use of improved inputs between bean and potato farming households. As presented in Table 10, the market participating households have used more improved inputs, which are improved seeds, inorganic fertilizers, and pesticides.

Table 10: Use of key improved inputs in production

	Beans			Potato			Pooled sampled		
Input (% of users)	Non-P	P	χ^2 value	Non-P	P	χ^2 value	Non-P	P	χ^2 value
Mineral fertilisers	40.7	59.2	8.70***	15.6	84.4	12.03***	19.4	80.6	88.29***
Organic fertiliser	64.1	35.9	0.13	14.2	85.8	3.68*	34.6	65.4	10.77***
Pesticides	42.8	57.2	5.49**	16.3	83.7	4.01**	19.8	80.2	65.09***
Improved Seeds	61.5	38.5	0.57	18.8	81.2	0.1	33.3	66.7	13.24***

*, **, ***, denote significance at 10%, 5%, and 1% levels, respectively

According to (De Janvry & Sadoulet, 2010), low adoption of mineral fertilisers is one of the causes of low land productivity and production in agriculture. The farmers whose use of these inputs is low consequently experience low production and barely participate in the output market. In the results presented above, households that have not used improved inputs were significantly represented in the group of non-participating households.

The use of improved inputs is facilitated by access to institutions such as extension service as well as households' access to physical infrastructures like market and road. Results showed that the extension officer has visited 22% of the households at least once in the season. The relationship between the contact with extension officer and households' market participation was found slightly significant (10% level). However, a proportional test across the households that have participated in markets and those who did not participate revealed no significant difference in terms of contact with extension officers. The significant chi-square might have come from the difference between the number of those who have met extension officer and those have not. This was contrary to the expected results.

Regarding access to infrastructure, 70% and 66% of the households in the total sample use less than an hour to walk to a local market and an all-weather road, respectively. Additionally, 58% of the households use less than an hour from the main road to the border to Uganda, using public transport. Results from the comparison of households based on their market participation showed a significant relationship between both variables for each crop and in the combined sample. As presented in Table 11, the chi-square value was significant at 1% and 5% (value equals 8.17 and 6.16 respectively) for bean crop. For potato, this value was only significant (10% level) for the access to all weather road (value equals 3.31). Travel time to the border with Uganda was also found significant among bean producing households and in the combined sample (value equals 8.68 and 9.14 respectively).

Table 11: Households' market participation and access to infrastructure

	Beans		Potato		Pooled sample	
Variable	Participated households (%)	χ^2	Participated households (%)	χ^2	Participated households (%)	χ^2
Contact with extension office						
No	77.8	0.05	72.7	5.45**	74.4	2.86*
Yes	22.2		27.3		25.6	
Time to all-weather road						
Less than or equal than 1 h	80.6	8.17***	67.8	3.31*	72.1	7.16***
More than 1h	19.4		32.2		27.9	
Time to market						
Less than or equal than 1 h	73.6	6.16**	79.7	0.49	77.7	14.58***
More than 1h	26.4		20.3		22.3	
Time to border						
Less than or equal than 1 h	70.8	8.68***	61.5	1.95	62	9.14***
More than 1h	29.2		38.5		38	

*, **, ***, denotes significance at 10%, 5%, and 1% levels, respectively

4.3. Marketing systems and women's participation

> "…*In the past agriculture was only for subsistence but today our members are trying to develop agricultural practices by using pesticide, fertiliser and RAB supports us by training our farmers and facilitating our access to improved seeds*." Leader of COABIKI cooperative, Musanze.

Findings from Focus Group Discussions (FGDs) and key informant interviews showed that respondents tend to compare their farming activities referring to the past and present time. In most of the cases, the past covered the period around the year 2000 and before, whereas the present time was referred to the period from around 2005 up to the time of the qualitative interviews in 2016. This is the period that has been characterised by the implementation of the national agricultural

policy and the second phase of the strategic plan for agricultural transformation (MINAGRI, 2004, 2009).

The comparison of periods related to agricultural change in Rwanda has also been used by Harrison (2016), classifying the post-genocide period into three phases. The first phase (from 1994-1999) during which the government's priority was to establish the order in resettlement and land sharing arrangement among the rural population, the second phase which covered the period from 2000 to 2006/7 and the third phase which had begun in 2007. In the second phase, the country started to establish the strategies and policies for economic growth that have been mainly implemented in the third phase. As highlighted in Harrison (2016), the latter phase marks many changes in the Rwandan agriculture, including the efforts to increase agricultural production that have been accompanied by growing links between smallholder farmers, inputs suppliers and crop buyers like processors and traders.

In the interview with the leader of COABIKI farmers' cooperative, she talked about the past, emphasising on the current time when agricultural practices are being improved with supports from some institutions like RAB: "…*In the past agriculture was only for subsistence but today our members are trying to develop agricultural practices…".* This makes one understands that farmers are conscious of the on-going transformation in the agricultural sector and that they may be benefiting from this. It is also clear that the changes in terms of agricultural practices among the farmers have brought a need to work with other actors in the sector, including private input dealers and public institutions. In the description by Harrison (2016), the third phase has been marked by the implementation of the Crop Intensification Program(CIP) through government agencies and donors have also played a big role. In other interviews, the intervention of the government through projects or local administration as well as the support of NGOs and international organisations has been also mentioned. The next quotations from key informant interviews echoed Harrison's description:

> *"There is a big intervention of the government. For agriculture to be successful, the government has played a big role. Before, we used to cultivate without fertilisers, but the government has encouraged us and trained us on how to use fertilisers*…" A representative of COAMIVU cooperative, Burera.
>
> *"Currently, we have more information from FAO, from CIAT … we have got improved varieties of beans* [talking about the high iron beans varieties promoted by one project of

CIAT] *and we have become more open,… we can negotiate their price."* Joseph, a member of Imbaraga cooperative, Musanze.

This situation in which farmers have begun to improve their agricultural practices and started to connect with new stakeholders with a target to reach and satisfy the market, reflects what Layton explains as a marketing system (Layton, 2011, 2015). This study followed the framework proposed in Cadilhon *et al*. (2003), in their analysis of vegetable marketing systems in Vietnam. The analysis has been limited to two aspects that are more relevant to the scope of this study. These are the actors in the marketing systems and how they connect with farming households, particularly with women farmers, given the prevailing social-cultural environment in which the system is embedded. In the next sub-sections, key actors who have linked with smallholder households in their endeavour to increase market participation are identified. The intensity of the connections is examined from the side of smallholder households through their participation levels in key inputs and output markets. Finally, the analysis sheds light on how gender issues as a part of the socio-cultural environment, have influenced women's integration in the marketing systems.

4.3.1. Actors that have worked with the households in inputs and output markets

The quantitative findings on the sources of inputs and the buyer of outputs allowed the identification of key actors directly working with farmers in both input and output markets. On the side of inputs, the results showed that the local market was the major supplier of the purchased inputs. In the category of the local market, we considered the local input dealers who supplied mineral fertilisers and pesticides to smallholder households but also the local labour market that supplied hired labourers. The latter mainly consisted of other farmers who were mostly landless or have very small agricultural land. There was no apparent difference between the suppliers of the purchased inputs for beans and potato crops and this led to the decision of considering both crops in the same system. This decision is consistent with other studies on marketing systems such as the one conducted by Kocho *et al*. (2011) on goats and sheep in Ethiopia as well as the other one by Jayant and Routray (2012), on fruits and vegetables in Thailand.

The results presented in Figure 5 show the suppliers of the four major inputs that have been purchased by the farmers. These are improved seeds, pesticides, mineral and organic fertilizers. The local market supplied to 62% of potato and bean farming households that purchased at least one type of these production inputs. The cooperative facilitated 24% of the households to get the

purchased inputs, 5%, and 9% of the households used the inputs that originated from other farmers, projects or government institutions as donations.

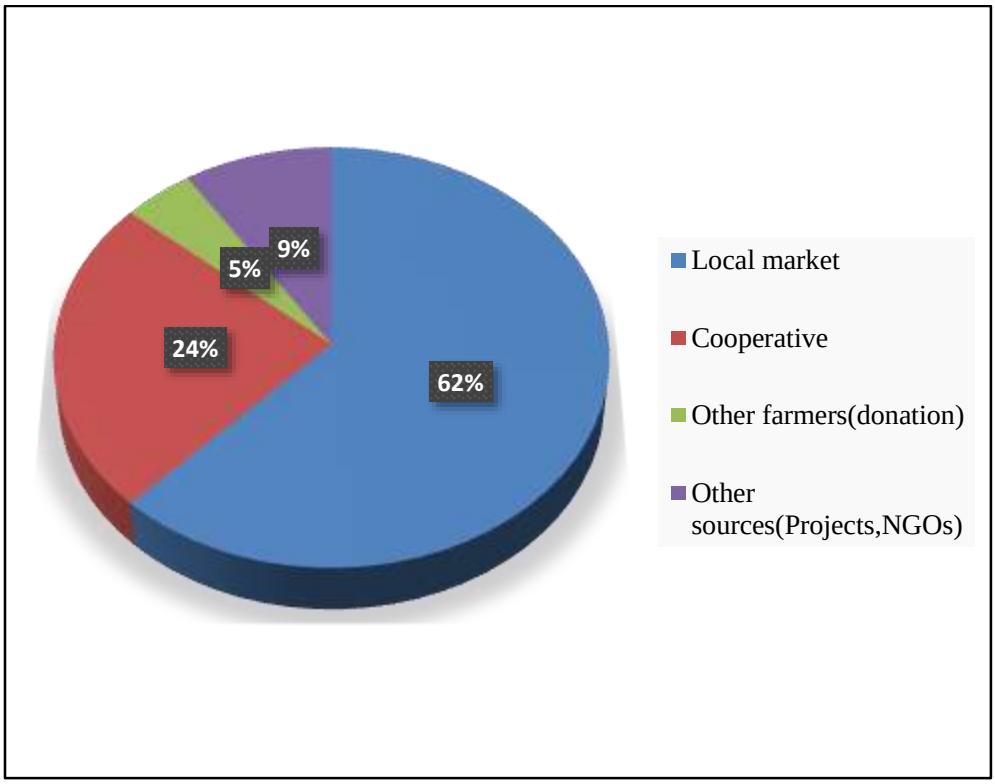

Figure 5: Suppliers of inputs for potato and beans farmers

Considering the number of households that have connected with the above sources of inputs, the proportion test showed that the local market has been the most significant actor for bean whereas the cooperative has been the most significant for potato (1% level). The results showing the importance of local markets reflects the possibility of a growing number of agro-dealers in the research area, which is in concordance with Harrison (2016). The involvement of cooperatives in inputs distribution is consistent with a study done by Verhofstadt and Maertens (2014) in the district of Muhanga in Rwanda. They found that farmers' cooperatives distribute inputs, mainly mineral, and improved seeds to their members. Additionally, the study suggested that one of the causes of satisfaction among these members was that they could access inputs and services through these cooperatives. Nevertheless, in the present findings, the proportion of households that linked to cooperatives to get purchased inputs was surprisingly very low compared to what was expected. This can be explained by the recent increase of agro-input dealers in the area but also the relatively low use of purchased inputs among the interviewed farmers.

Concerning the output commercialisation, results in Table 12 show that local market and farmers' cooperatives have been the major actors that worked with smallholder households. Around 74% and 44% of bean and potato producing households respectively have sold their produce directly to the local market. The cooperative facilitated 52% and 17% of potato and beans farmers respectively, in their process to reach the output market. It was noted that intermediaries have also contributed (though at small extent) in the commercialisation of both potato and beans. Other farmers have also participated as buyers of beans and potato but their role was not significant.

Table 12: Actors in outputs market

Category of actor	Beans (% of households)	Potato (% of households)	Pooled (%)
Local Market	73.61	44.06	53.95
Cooperative	16.67	51.75	40
Others farmers	5.56	0.7	2.33
Intermediaries	4.17	3.5	3.72
Total	100	100	100

For potato crop, the number of farmers who interacted with the local market is higher than expected and the findings showed no significant difference between this number and the one among households that sold through cooperatives. One reason to this is that some farmers have not been faithful to the cooperative as the members are generally supposed to sell their produce through their cooperatives. Another possible explanation is that by the time of this study, potato marketing channel was being restructured in order to leave the commercialisation under the hands of private companies through what is locally known as "collection centers; *amakusanyirizo*". So by that time, the new channel was not yet fully working but some potato farmers could have taken advantage of the disturbances and sell outside their cooperatives.

The comparison of both crops showed that the number of potato farmers who sold through cooperatives was significantly higher (at 1% level) than that of bean farmers, indicating that more

potato farmers have worked with cooperatives. It also shows that compared to bean, the marketing of potato follow more structured channel, allowing more potato farmers to access to market information. In an interview with a key informant from an organisation of farmers, the role of cooperatives in facilitating potato farmers was highlighted:

> *"Nowadays, farmers' organisations inform the members about market prices. As an example, I know the daily price of potatoes. I have some connection in the market of Kigali."* Joseph, Imbaraga organisation, Musanze.

A part from the access to market information, scholars have emphasised on various advantages for smallholder farmers who operate in cooperatives. These are for instance the better access to storage and transport facilities as well as more bargaining power to get better prices (Kaganzi *et al*., 2009; Markelova *et al*., 2009). In Rwanda, studies by Verhofstadt and Maertens (2015, 2014) showed that cooperatives contribute to poverty reduction and agricultural performance of their members. The authors also investigated the reasons which hinder farmers to adhere to cooperatives and found that the majority of non-members would like to adhere but they are limited by the land size, lack of information about cooperative formation, lack of membership fees and lack of time (Verhofstadt & Maertens,2014). So, in light of the studies done in other regions of the country, potato farmers who are more working through cooperatives, can be considered as better-off in terms of access to production facilities but also in terms of commercialisation outcomes. However, there have also been cases of mismanagement of cooperatives in some areas which may have reduced the trust of farmers and consequently lead to commercialisation outside cooperatives. Additionally as discussed by Verhofstadt and Maertens (2015), collective action also requires farmers to have a certain size of land which may have been a limitation for bean farmers whose average land size is significantly below that of potato farmers.

4.3.2 Other supporting actors

Results also showed a number of formal and informal institutions that have worked with the bean and potato farming households. As given in Figure 6, they include the informal saving groups, commercial banks and microfinances, farmers' organisation, private companies, Government project, NGOs and the national research institution which have mainly facilitated in terms of trainings and access to finances. The findings show that more potato farmers have worked with informal savings, banks and farmers' organisations compared to bean producers.

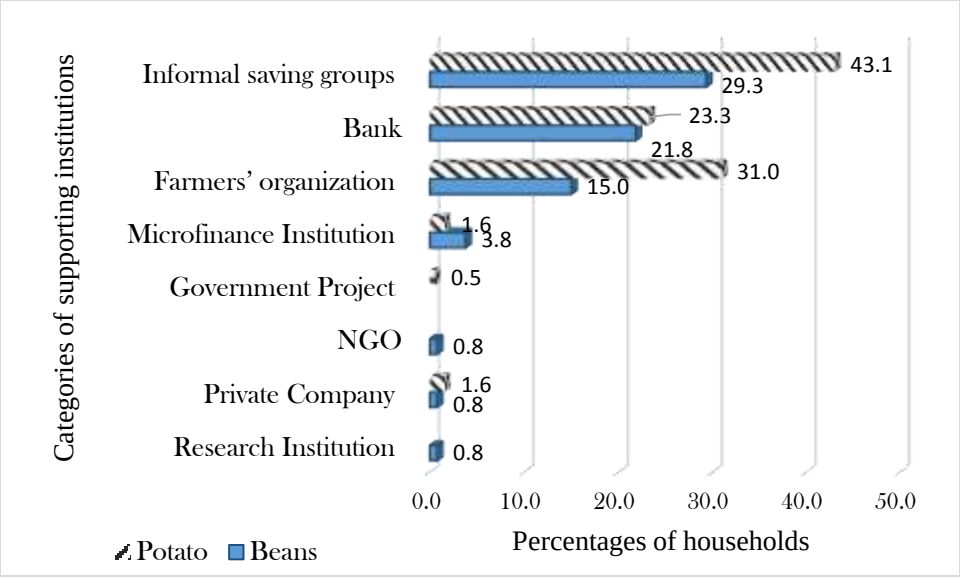

Figure 6: Institutions that have worked with farmers

The farmers who have direct links with NGOs, Government projects or research institutions were very few. The major reason to this is that most of these institutions work through cooperatives as it was noted from various interviews with key informants. As observed by Harrison (2016) the integration of farmers in the marketing channels is mainly operationalised through cooperatives. Therefore, the links between the smallholder farmers in this study were either made directly with the various actors or could have been through their cooperatives for those who are members. Just like explained in Cadilhon *et al.* (2003), these links were primarily the tangible products such as commercialised output and production inputs that flowed between farm households, inputs dealers, cooperatives and various buyers. In addition, the supporting institutions have provided intangible elements like training and technical support and credits.

4.3.3. Household participation in input markets

In the whole sample, around 54% of the households have participated in inputs market for at least one type of the purchased inputs including labour. As presented in Figure 7, around 76 % of the potato farming households have purchased pesticides while 86 % and 52% bought mineral and organic fertilisers, respectively. For beans, around 10% have purchased pesticides, around 12% and 30% have bought organic and mineral fertilisers, respectively. In the production of both crops, the respondents have utilised hired labour. The results showed that approximately 43% and 30% of potato and bean producing households have respectively participated as buyers in the labour market.

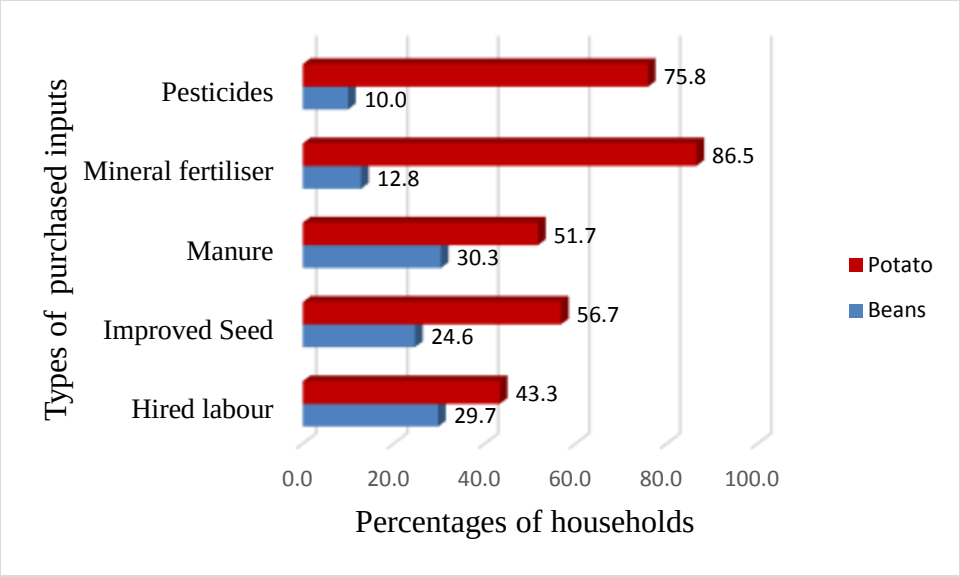

Figure 7: Household participation in inputs markets

In the pooled sample, the level of participation to input markets was not as high as expected, the number of participants was significantly superior to that of non-participants. Actually, given the effort that has been put in increasing farmers' access to inputs, this level was expected to be much higher. However, the situation is not unique to Rwanda as Binswanger-Mkhize and Savastano (2017) found almost similar results in their analysis of agricultural intensification in African countries among which were Uganda, Tanzania, Ethiopia and Malawi. In terms of improved inputs, Malawi was the best with 61% and 76% of households that have respectively used improved seeds and mineral fertilisers. In Ethiopia, 23% and 41% of its farmers used improved and mineral fertilisers while in Uganda and Tanzania the use of these inputs was the lowest with around 18% and 12% of households that used improved seeds and agrochemical.

In the present study, findings from FGDs indicated that for both crops, the participation of households in input markets was limited by a number of challenges including unaffordable prices particularly due to the poor infrastructure and unavailability of input dealers in some villages:

> *"The transport for fertilisers is expensive, as we have one seller in the whole sector, and the road to reach there is bad…. it becomes unusable, particularly in rainy seasons, and getting a motorcycle* [paid] *for transport becomes a challenge…"*. FGDs, Men (Gakenke).

The results also revealed that the level of input market participation can vary depending on the crop. The proportion test comparing bean and potato farming households' participation in inputs

market showed that bean farmers have significantly lower level at 1% level (*z-value* = -3.64). The difference in the use of purchased inputs between bean and potato farming households is consistent with the research by Riwthong *et al*. (2016) in Thailand, who showed that farmers with higher level of output market participation mostly use large amount of pesticides. In this study, potato farmers had higher degree of output market participation and therefore used large quantity of purchased fertilisers and pesticides. This could also be explained by a higher level of income among these farmers, as they generally use agricultural income to purchase the inputs.

The findings also show that though more potato farmers have used hired labour, participation in labour market was still low which indicates the importance of family labour in crop production. This implies limited possibility of household members to diversify their source of income outside farming. It also shows that Rwanda still has more steps to make as evidence from Ghana, another African country in agricultural transition showed that smallholder farming is largely becoming mechanised (Kansanga, 2017; Kansanga *et al*., 2018).

4.3.4 Households participation in output markets

Results indicated that 56% of the households in the pooled sample have participated in outputs market as sellers while 44% have consumed all their production. Calculation of the Household Commercialisation Index (HCI) showed that among those who have participated, 62% of the households have sold a half or more of their produce. On average the households that participated in output markets have sold around 55% of their production with a minimum of 7% and a maximum of 100%. As shown in Figure 8, more potato producers have participated in output markets compared to those who produced beans (80% versus 34%). The extent of their participation, which is indicated by the HCI, also showed that for those who have participated, the average farmer has sold 62% and 41% of his/her production of potato and beans, respectively. A two sample Student test *(t*-test) comparing the HCI of these farmers confirmed a significant difference at 1% level between the two groups, leading to the conclusion that the intensity of participation in output market is higher among potato farmers.

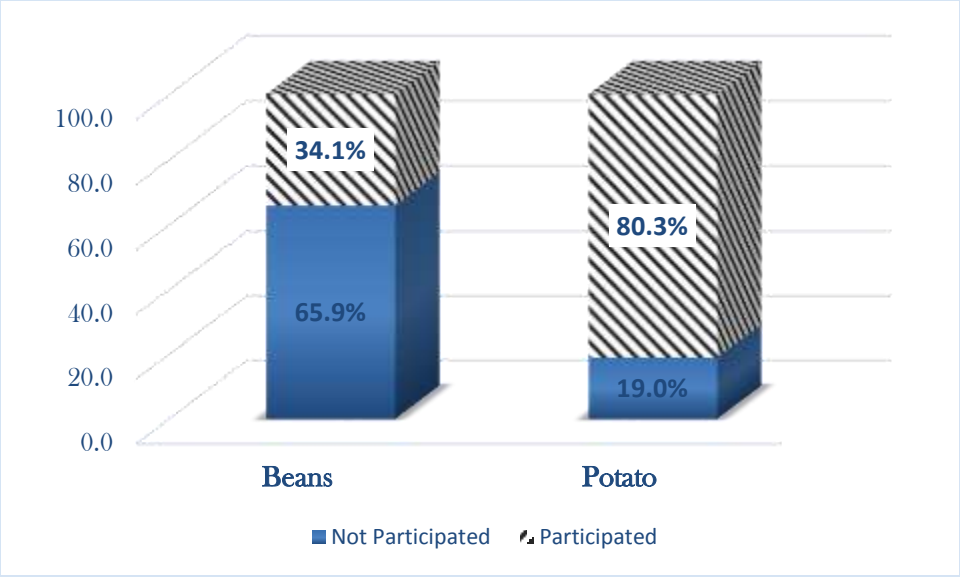

Figure 8: Participation of households in output market by crop

Households were put in categories according to their levels of participation in output markets. The results in Figure 9 show that around 20% and 21% of bean and potato farmers have sold less than 50% of their produce. On the other hand, around 14% and 60% of bean and potato producers respectively have sold a half or more of produce. Again, the difference between the proportion of potato and bean farmers who have sold more than a half of their produce has been statistically significant at 1% level. Therefore, for potato crop, the high level of participation of households is not only about the number of those who sold but also the quantity they sell. The 60% of potato farmers can be qualified as market oriented farmers since they have sold a half or more of their production (Bekele *et al*., 2010). This has been confirmed even from the FGDs, where participants mentioned market orientation for potato among the recent changes that were experienced in the agriculture:

> "*... In the past, we used to grow Irish potatoes on a small scale, but now we grow with a purpose to commercialise the production….Whatever the quantity produced, it is sold and we remain with a small proportion to sustain our families*". FGD, Women (Burera).

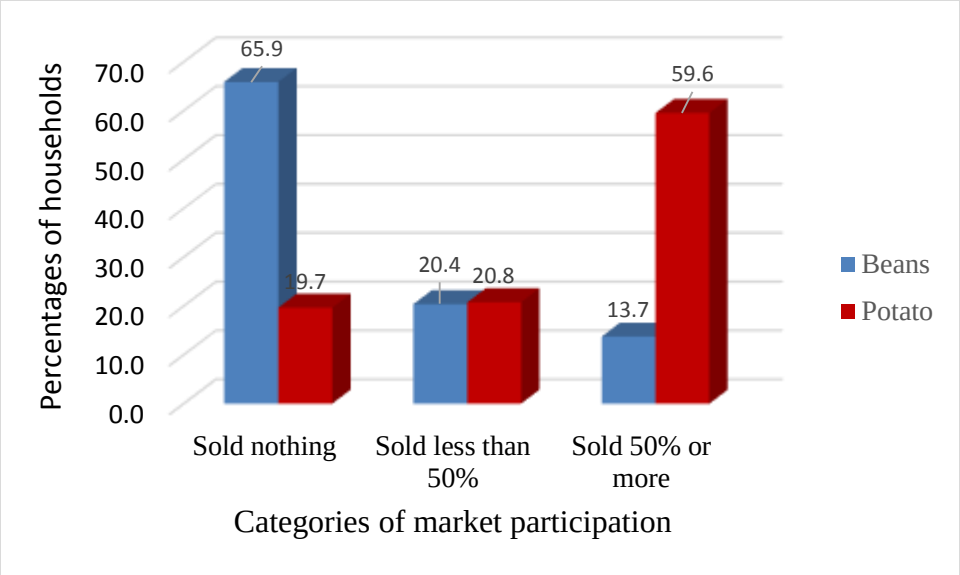

Figure 9: Categories of farmers by degree of output market participation

In the group discussions, the low level of output market participation for beans was indirectly captured. The findings revealed that bean commercialisation mainly occurred when the households needed to buy small items such as soap, salt or when they want to pay health insurance, which would explain the lower output market participation for this particular crop. The next quotation was extracted a discussion on bean commercialisation, and when farmers were talking about this crop, they quickly thought about consumption at household level, referring to family subsistence and commercialisation of a small amount:

> "*If I need to pay like a health insurance I would have to sell part of my bean production; this might take like a bag of 20 Kg and I have five people to feed ….*" FGD, women (Gakenke).

4.3.5. Women's participation in input markets

Results on women's participation in inputs markets showed that for both crops, women and men's participation is not at the same level. In households that are headed by men, 52% of the participating households (regardless of the crop) have involved men only and around 24% and 23 % have respectively involved women only and both spouses. Among potato producers, around 55% of households reported that only men have interacted with inputs suppliers, while 20% and 24% of the households in this group have respectively involved women alone and both spouses. For beans, around 49% and 29% of households have respectively involved men and women whereas, in 20% of the households, both spouses have been involved in the input market.

A proportion test was done with a particular focus on the proportions of the households that involved women and those which involved men in the inputs markets. The null hypothesis was that the proportion of these two groups were equal (H0= prop [Husband]-prop [Wife] =0). The results displayed in Table 13 show the proportion for each crop and the results from the tests. For beans, there was a significant difference (at 10% level) between the proportion of men and women who have been in contact with the inputs dealers. This indicates that the number of wives who participated in the input markets for bean was statistically inferior to that of husbands from the same category of bean producers. Among potato producing households, the difference between the proportion of men and women has been significant at 1% level. The interpretation of this is that for potato, husbands are more involved than wives though another important proportion of households reported having involved both spouses. However, even when the proportions of households that involved men and those which have involved both spouses are compared, the former remain significantly superior (at 1% level). A similar test for the combined sample gave this significant difference between husbands' and wives' participation, indicating gender inequality in terms of links to input suppliers within households that are headed by men. This can be mainly due to the fact that a good number of these households have been supplied through cooperatives whose members are generally the husbands (household heads).

Table 13: Input markets participation among women from male-headed households

Crop	Husband (%)	Wife (%)	Both spouses (%)	Other male member (%)	Other female member (%)	Total
Bean	48.8	28.7	20.0	0	2.5	100
Potato	54.8	20.0	24.3	0.9	0	100
Combined	52.3	23.6	22.6	0.5	1.0	100

Pearson chi2(4) = 5.8254 Pr = 0.213, Cramer's V = 0.1728

Proportion test

Beans: Husband vs Wife*:* z = 1.54*

Potato: Husband vs Wife: z = 2.88***

Potato: Husbands vs Both spouse: z = z = 2.74***

Combined sample : Husband vs Wife : z = 3.29***

*, ***, denote significance at 10 % and 1% level, respectively

In female-headed households, 78% of those who purchased inputs have involved only women in the input market, 6% have involved male members of the households (not spouse) and 16% have involved other female members of the households. For both crops, there was a significant difference in the participation of women in agricultural input, as the household members who have been in contact with inputs suppliers when compared to other members. This was expected because, in female-headed households, the women heads are mostly the only adults available to deal with farming. A significant difference appeared instead when the two crops were compared in terms of the proportion of women who are involved in inputs markets. The percentage of households that engaged women was higher and significant among potato farmers, compared to those in bean producing group (5% level, z-value = 2.01). This is explained by the low participation of bean producing households, particularly those which are female-headed. A major limitation for female-headed households was financial capacity and this was not only for those for bean producing households but also for potato. Below is how women expressed the problem when they were talking about using purchased inputs during one of the group discussions:

> "*…the quantity of fertiliser I may need for my farm can cost around 10,000Rwf, yet we do not have anything at home that I can sell to get such an amount, so I decide not to apply it*". FGDs, Women (Gakenke).

When these women were asked about the various sources of income they can use to get money for inputs, they mentioned agriculture as it could be understood from the quotation below from Burera group. This indicates that their level of participation in inputs market remains highly dependent to agricultural production and commercialisation:

> "*By the time I fail to get enough production to sell, I fail to buy inputs such as fertilisers*". FGDs, Women (Burera).

Most of the available studies related to women' access to inputs have highlighted that gender differential in this area is mainly moderated by access to other factors such as credit (Olakonjo, 2017; Peterman, Behrman & Quisumbing, 2014). This study corroborates their findings by showing that limited financial capacity plays a significant role in preventing women to link with input markets and this particularly applies to women from households that are headed by women. Concerning those from male headed households, their low participation is particularly explained by their husbands' membership in cooperatives. However, this can influence agricultural production as research done in Burkina Faso has shown that in a system where the household head

is the one who receives an input, he is more likely to unequally allocate it on plots (Haider, Smale & Theriault, 2018). Finally, the findings revealed no particular gender norms that may be causing this low participation, unlike what is found in the literature on related topics (Mersha & Van Laerhoven, 2016; Fletschner & Mesbah, 2011; Doss, 2001).

4.3.6. Women participation in output market

Results in Table 14 show the levels of women and men participation in output markets from male-headed households. In the combined sample, around 42 % of the households participating in output markets have involved only men whereas around 28% and 29% of these households have involved women and both spouses, respectively. For beans, around 27% of the participating households have involved husbands only and in 49%, women have been engaged in the transactions. In approximately 49% of households that sold potato, only husbands have sold the output while in 17% and 32 % of the households, only women and both spouses have respectively participated. The tests on whether these proportions are statistically different showed that in the combined sample, the proportion of households that engaged men only was higher than those that involved women only. This difference was significant at 10% with a *z-value* of 1.6. The same test also revealed that the proportion of households which involved men in potato markets was significantly superior (at 1% level) to those who involved women. Moreover, the proportion of men was higher and significant compared to that of households which engaged both spouses.

Table 14: Women and men' participation in output market

Crop	Men	Women	Both spouses	Other male members	Other female members	Total
Beans	17	31	15	0	0	63
	26.9	49.3	23.8	0.0	0.0	100
Potato	61	21	40	1	1	124
	49.2	16.9	32.3	0.8	0.8	100
Total	78	52	55	1	1	186
	41.7	27.8	29.4	0.5	0.5	100

Pearson chi2(4) = 22.61***

Proportion test

Beans: Men vs Women: *z* = -1.4810*

Potato: Men vs Women: *z* = 2.5735***

The above quantitative results show that for women who are in male-headed households, their level of participation in output commercialisation differs depending on the crops, implying a difference in how they interact with the market. In the overall sample, the results indicated that husbands are the one who interacted more with the buyer of the agricultural produce. In bean producing households, more women than men have interacted with the market while the contrary was found in potato producing households.

Based on the literature, one of the explanations for this difference can be that men tend to take control of crops as they become more commercialised (Fischer & Qaim, 2012; Quisumbing & Pandolfelli, 2010). However, for the contradictory results at crop level, detailed analysis of the qualitative information revealed another possible explanation; in some households, there are gender norms that have an influence on crop management and commercialisation. The quotation below shows that in some locations of the study area, beans and potato are considered a woman's and man's crops respectively:

> "*There are villages, near the forest where it is known and indisputable that potato crop is a men's property and beans are for women. When a woman has planted beans, a man won't ask about it, and for potato, the wife will not ask the husband*". FGD, Women (Burera).

The findings about beans are consistent with Waldman, Kerr and Isaacs (2014) who observed that for this crop, women engage in most of the production activities in Rwanda. However, Doss (2002) found slightly different results in her study in Ghana. She found that while there were some crops classified as men's, there was none that was considered as a woman's crop. Other researchers have argued that that women, either subsistence or market oriented, the food production tend to be attributed to women (Carr, 2008). In the present study, this can be another possible explanation to the gendered crop management and output market participation because as understood in the next quotation, beans are still considered as being mainly for consumption:

> "*... she* [the wife] *can sell a proportion of beans and reserves others because she has to feed children at home; in those areas, beans are planted for home consumption but can be sold to buy things like salt or soap*". FGD, Women (Burera).

Regarding potato crop, the qualitative findings showed that women rarely participate in the marketing transactions. Potato is considered as a man's crop and this is first due to the farmers' perception of gender roles, by which a man is perceived as households' breadwinner. In such case,

men remain the key members of households who can easily deal with income including that earned from farming. Where women do participate, either the man works in a different domain or he has migrated or the woman participates as a helper in on-farm activities or supervising and paying workers as stated by the farmers. This situation is consistent with the concept of feminisation of agriculture in where women are pushed to increase their labour in farming activities while men look for off-farm employments:

> *"..those who do it* [sell potato] *are those whose husbands are busy with other works ..., otherwise a husband cannot ask his wife to take the production to the selling point. Most often it is the responsibility of men. How many women can you find at the collection center*[1] [laughing]*? Very few*". FGD, Women (Burera).

In female headed households, women heads were the major actors who have linked with the output markets. Thus in cases where the households have participated, the contact was done by the woman only for the case of bean whereas for potato, they were involved in 78% of households. The big difference between the households that are headed by men and those headed by women is that for the latter, the participation in markets has been very low. This observation has been also made by Marenya *et al*.(2017) in their analysis comparing the households headed by men and those headed by women in Ethiopia.

4.3.7. Issues related to the gendered participation in the marketing system

Qualitative findings revealed other gender issues which are related to the market participation, particularly within male-headed households. They have been raised during the FGDs and women considered them as impediments to agricultural transformation. These are inequalities in terms of farm and household works as well as the limited access to agricultural income

Inequality in labour supply

Findings from the discussions showed that women's contribution has increased especially for potato crop. This was perceived in the quotation below where men described them as "being actually more responsible" and that "nowadays, they work together". Nevertheless, men could also consider women as "helpers", especially when it comes to the activities like harvesting and

[1] By the time of FGDs, some collection centers were already functioning and farmers were directly taking their potato to sell it there.

managing hired workers. This reflects the thesis by Chant (2014) on the feminisation of responsibility that women are becoming more responsible for dealing with poverty through productive works.

> "Nowadays w*e work together,… I cannot go to harvest alone; I go together with her, even with workers who carry the potatoes to the selling point,… after selling, she comes and helps me in paying workers. She must come to help me, she is actually more responsible*". Faustin, FGD Men.

In other cases, one could understand that some of the men participate in farm activities just to help their wives, as if on-farm work is supposed to be on women's shoulders only. They may both work together on field, then in the afternoon, men get more time for leisure, while women continue with their traditional reproductive tasks in the household:

> "*We usually work together on the farm: planting potatoes, beans, .. almost everything. But, in the afternoon, you see yourself that I have just taken a bath, I'm now heading to Murambo* [village center] *for a bottle. When I have spent the whole day helping my wife on the farm, and she sees me leaving…, she does not argue.* " FGDs, Ngabo (Gakenke).
>
> "…*after spending the whole day together in the field, the time use differs between wife and husband. From the field, women go home to fulfil other responsibilities like cooking and take care of the children, and men do not do such work after spending the day on the farm. Women work many more hours than men*". FGDs, Men (Burera).

It was clear that men were conscious of the increasing workload for the women. On the question whether they could participate in household tasks that are usually for women, the reactions were different. Men, mostly in couples that have no children, said that they usually help women in household chores. However, the majority of the men in FGDs have remained sceptical of that idea because they feared criticism from neighbours, friends or relatives as expressed below:

> "*... helping wives does not occur everywhere, approximately 20% may be helping their wives in their household duties because people may think that this husband is being ruled by a wife. A man cannot sweep or clean dishes while his wife is doing other things*". FGDs, Men (Burera).

The difference in workloads between women and men farmers was found by Arora and Rada (2017) in Mozambique. Their study showed that time constraint resulting from the workload among women and unequal participation in household chores have a negative effect on agricultural

output. Actually, the women who have increased their contribution in productive work, specifically in agriculture, do not have time to rest , network or interact with other actors in the marketing system at the expense of their agricultural labour and productivity. In the group discussions, women emphasised that this inequality in responsibility sharing is a constraint to agricultural transformation.

Inequality in income control and use

Though the women were considered as being more responsible, their increasing contribution has not improved their position in terms of decision making either in production or over agricultural income:

> "*A husband is the one who determines what to plant …., still he is the one who determines what to give his wife, maybe thanking her for what she does on the farm…*". FGD, Women.

Wives' access to agricultural income was even perceived as a reward from their husbands for their contribution in farm activities, just like in the quotation above. In extreme cases, husbands may decide not to compensate their wives and the latter choose to keep quiet in order to avoid conflicts:

> "*…it would be better working together and sharing* [the income]. *…when he sells produce, the wife expects him to bring something home, and then, whatever he brings, the wife accepts and keeps quiet to have peace at home…in the case where she gets nothing, she has to keep calm, too. There is nothing else she can do*". FGD, Women (Gakenke).

These results on the access and control of agricultural income showed a gender gap in power relation. The quotation from FGDs reveals that men have control over the income and could decide how to spend it while women though unhappy, decide to keep quiet, avoiding conflict. This indicates that women have a low bargaining power over the income from agriculture. The finding is consistent with the "feminisation of obligation" by Chant (2014); women are obliged to "do nothing" and accept the situation to have peace at home. This unbalanced power relation suggest that increased women's contribution in agriculture that accompany household's market participation, may also cause emotional stress (Arora & Rada, 2017).

Though these women try to avoid direct conflicts, research in other African countries showed that such conditions where women farmers do not access to agricultural income could negatively impact market-orientation at household level. This for example the cases of chili pepper and French beans production in Kenya, where women withdrew their labour, disturbing the supply

chain and the quality of these commodities (Dolan, 2001; Rubin & Manfre, 2014). In these cases, the labour was diverted to subsistence production or to social work in women groups and churches. In the Rwandan case, women in the FGDs considered this lack of economic incentive for their labour as an impediment to agricultural development. They were not able to withdraw their labour or any other type of contribution, but they are conscious that the inequality in income sharing has a negative effect on their progress towards market-oriented farming. Like expressed below:

> "*...there are times when money from harvest is given, the husband takes it all and does not even give his wife a single coin and forgets that she is the one who struggled hard with the land... That is an impediment to agricultural development*" FGD, Women (Burera).

4.4. Determinants of output market participation

4.4.1. Double-hurdle model diagnostics

A likelihood ratio test to confirm whether the double-hurdle model is the better alternative compared to the Tobit model was performed. With the values that equalled 112.64, 73.98, 73.48 for pooled, bean and potato models respectively, the null hypothesis was rejected in favour of the idea that Double hurdle model was appropriate.

A Wald Chi-square statistic of the model was used to test if the specified independent variables have an effect compared to the intercept. For the pooled and crop-specific models, the Chi-square values were significant at 1% level indicating that at least one coefficient of the independent variables is different to zero as presented in Table 15.

4.4.2. Results from Double-hurdle model estimation

Although double hurdle models involve separate estimation of the first and second hurdle, it does not imply separability in the interpretation of the estimates (Burke, 2009). First, separate interpretation of the coefficient estimates would mean that the partial effect of a variable that predicts commercialisation on the unconditional expected value of the decision to participate would be a function of the results in the first hurdle even if it does not appear in the Probit model. Second, some variables may have predictive influence and countervailing impacts on each of the two hurdle models and have different signs. In this circumstance, the direction and magnitude of the overall impact of such variables cannot be well understood unless the interpretation is done simultaneously. Hence, results from the first hurdle (probit) and second hurdle (truncated regression) are interpreted simultaneously. In the next sub-sections, the results from regression

diagnostic tests are presented (Table15), followed by the results from the model estimation (Table 15 and 16).

Tables 15 and 16 present the double hurdle model estimates of the households' participation in output markets. In particular, Table 15 presents results for the first hurdle which captures the determinants of farmers' participation in the output market. The overall results for market participation are presented in columns 2 and 3 of Table 15. Columns 4 and 5 present estimates of determinants of market participation among bean producing households. The last two columns of Table 15 present estimates of determinants of potato farmers' participation in the market.

Table 15: Determinants of market participation

	Overall (N=389)		Bean (N=211)		Potato (N=178)	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Women and Household characteristics						
Age	-0.009	0.006	-0.014	0.009	-0.007	0.010
Gender of the head(1=F)	-0.173	0.302	-0.222	0.437	-1.099*	0.604
Schooling years	0.073**	0.035	0.020	0.046	0.297***	0.080
Marriage status	0.006	0.223	-0.044	0.334	-0.052	0.420
Main occupation	-0.072*	0.039	-0.044	0.058	-0.228***	0.080
Household size	-0.094**	0.037	-0.086*	0.050	-0.183***	0.070
Assets and improved inputs use						
Land size	0.640***	0.237	0.576**	0.292	0.390	0.455
Used improved inputs	0.572***	0.186	0.542**	0.236	0.996***	0.383
Decisions on agricultural technologies (Base=No input)						
Input in very decisions	0.073	0.298	-0.182	0.494	0.640	0.523
Input in some decisions	0.114	0.302	0.360	0.510	0.059	0.451
Most of the decisions	-0.126	0.327	0.161	0.494	-0.556	0.504
Into all the decisions	-0.066	0.281	0.121	0.468	0.502	0.500
Responsible of the crop (Base=Male adult)						
Woman alone	-0.468**	0.233	0.021	0.286	-1.945**	0.812
Woman with other members	-0.068	0.202	0.066	0.324	-0.721	0.447

Table 15: Determinants of market Participation-Continuation

	Overall (N=389)		Bean (N=211)		Potato (N=178)	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Institutions and access						
Agricultural training	0.281	0.202	0.367	0.277	-0.081	0.404
Group membership	1.382***	0.171	1.253***	0.236	1.818***	0.325
Contact with extension officer	0.016	0.091	-0.033	0.147	0.427	0.511
Time to local market	0.028	0.211	0.299	0.269	0.126	0.473
Time to usable road	-0.313	0.201	-0.559*	0.299	-0.680*	0.373
Time to Border	-0.731***	0.263	-1.337***	0.461	-0.421	0.460
Location (Reference: Burera)						
Gakenke	-0.059	0.307	0.860*	0.457		
Musanze	0.682**	0.335			-0.391	0.489
_cons	0.269	0.455	-0.132	0.705	1.414	0.864

Overall χ^2 = 158.51; Prob > chi2 = 0.0000

Bean χ^2 = 75.58; Prob > chi2 = 0.0000

Potato χ^2 = 66.23; Prob > chi2 = 0.0000

*, **, ***, denote significance 10%,5%,1% significance level, respectively

On the other hand, Table 16 present estimates of covariates that condition commercialisation of the two crops. In particular, columns 2 and 3 present overall estimates for the level of market participation by smallholder bean and potato farming households. Independent estimates of covariates of beans and potato market participation are shown in columns 4 and 5 and columns 6 and 7, respectively.

Table 16: Extent of market participation

	Overall (N=389)		Bean (N=211)		Potato (N=178)	
Variables	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Women and Household characteristics						
Age	0.001	0.001	0.000	0.002	0.001	0.001
Gender of the head	0.070	0.051	0.066	0.066	0.055	0.061
Schooling years	0.016***	0.006	-0.003	0.007	0.018**	0.007
Marital status	0.016	0.045	0.074	0.054	-0.010	0.048
Main occupation	-0.001	0.007	-0.002	0.009	0.001	0.008
Household size	-0.009	0.008	-0.005	0.009	-0.010	0.010
Assets						
Land size	0.060***	0.015	0.047	0.033	0.061***	0.017
Number of transport assets	-0.029	0.027	-0.073**	0.030	-0.016	0.025
Having phone	0.074**	0.033	0.070*	0.039	0.072*	0.039
Rearing livestock	-0.021	0.030	0.037	0.038	-0.033	0.034
Institutions and access						
Market price	0.000	0.000	0.001***	0.000	0.000	0.000
Agricultural training	0.081**	0.036	0.161***	0.049	0.016	0.041
Contacts with extension	-0.001	0.013	-0.005	0.020	-0.002	0.015
Group membership	0.083**	0.034	0.071**	0.033	0.045	0.042
Market	-0.037	0.037	-0.011	0.041	-0.008	0.049
Road	-0.007	0.033	0.034	0.052	-0.035	0.038
Border	-0.049	0.033	-0.051	0.038	-0.045	0.038
Used credit	-0.024	0.035	0.035	0.037	-0.049	0.042
Agricultural income	0.012***	0.003	0.010**	0.005	0.009**	0.004
Overall = 158.51; Prob > chi2 = 0.0000 Bean = 75.58; Prob > chi2 = 0.0000						
Potato = 66.23; Prob > chi2 = 0.0000						

*, **, ***, denote significance 10%,5%,1% significance level, respectively

Table 17: Extent of market participation-Continuation-

	Overall (N=389)		Bean (N=211)		Potato (N=178)	
Variables	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Responsible of the crop (Base=Male adult)						
Woman alone	-0.192***	0.037	-0.168***	0.053	0.011	0.098
Woman with other members	-0.017	0.035	-0.144***	0.054	0.014	0.038
Decisions on the quantity (Base=No input)						
Input in very decisions	-0.048	0.046	-0.010	0.069	-0.045	0.044
Input in some decisions	-0.041	0.055	0.043	0.074	-0.093	0.063
Most of the decisions	-0.026	0.068	-0.077	0.093	0.028	0.056
Into all the decisions	-0.094*	0.056	0.066	0.070	-0.135**	0.063
_cons	0.353***	0.088	0.000	0.093	0.504***	0.105
/sigma						
Cons	0.191***	0.009	0.123***	0.010	0.181***	0.011

Women and households' demographics

Three women and households' characteristics significantly influenced the decision to participate in the output market. The significant variables include the number of years in the formal education of women, their main occupation and the size of their households. Only education level of women influenced the extent of their households' participation in the output markets.

Years of education among women farmers was positive and significant in the probit and truncated regressions for the overall and potato models. This result is plausible because the direction of the relationship was expected. The estimation of the marginal effects show that in the combined sample, an increase in education level by 1 year results to higher likelihood of households' market participation by 1.6 % but also increases their intensity of participation by 1.5% (Table 17). Among potato producers, 1 year of formal education for women farmers would increase the probability of households' market participation by 4% and their commercialisation by 1.7%. In other words, the likelihood of participation in the output market and the level of commercialisation increases with an increase in years of schooling of the women farmers.

Education enhances individual understanding of the importance of commercialisation and helps farmers in grasping new information whether related to production or marketing. Education also improves women farmers' ability to contribute (directly or indirectly) in intra-households decisions. This could be done in two ways, by improving the bargaining ability of women in the process of decision making with men within households or by facilitating women farmers to access information through reading newspapers or manuals on agricultural technologies for example. Hence, education could allow these women to bargain for decisions that may allow households to take advantage of opportunities emerging with the agricultural transformation efforts in the country. For instance in potato households, educated women are likely to be aware of the prevailing market prices and the commercial value of potato production which, in turn, influences their households' decisions to market participation. This finding is consistent with the results by Mmbando *et al*. (2015), who found a positive relationship between market participation among maize farmers and the education level. Adeoti *et al*. (2014) and Rahut *et al.* (2015), also showed that education was a cardinal determinant of commercialisation among farmers in Nigeria and Eastern Himalayas, respectively.

Women's main occupation significantly influenced market participation in the overall model and among potato farming households. However, its influence on the extent of potato commercialisation was insignificant. This implies that the households with women whose main occupation is in non-farm activities are less likely to participate in the output market, specifically among potato farmers. It could have been that women who have their main occupation in off-farm employment supplied less of their labour to potato production. This could have led to agricultural productivity gaps between individuals with farming and off-farm activities as their primary occupations. The productivity gaps, in turn, results in market participation gaps. Stated differently, when the main occupation of the adult woman (spouse or head) in the household is farming, it is a significant inducement to market participation among the smallholder farmers. This reflects the importance of women's contribution to crop production for the growing commercialisation of food crops, particularly potato. It is also consistent with the qualitative data from the FGDs in Burera where men said that wives are even more responsible for the crop. The findings of this study corroborates with the concept of "feminisation of responsibility" by Chant (2014).

Household size was negative and significantly associated with the probability of output market participation among the sampled beans and potato households. However, it was insignificant in

determining the extent of commercialisation in both bean or potato market, and the results were the same even for the overall model. As per the estimated partial effects reported in Table 17, the interpretation of the results in the first hurdle is that an increase in household size by one person leads to around 2% reduction on the probability of the household's participation in the market for both crops and in the combined sample. A larger household size implies many people to feed. This means that large-sized households are unlikely to participate in the output market. The primary purpose of engaging in farming by large-sized households may possibly be to enhance household self-food sufficiency and food security which may reduce the likelihood of market participation. In addition, the result suggests that in these households, consumption decision may be superior to market participation decision because farmers are more likely to sell what their households cannot consume. Rahut *et al*. (2015) reported a similar result while Rabbi *et al.* (2017) reported that larger household size increases the probability of market participation.

Gender of the household head was negative and significantly associated with the probability of market participation among potato farmers but insignificant in influencing the level of potato commercialisation. In contrast, the gender of the household head was positive and insignificant in influencing market participation for both crops. The negative coefficient for potato market participation indicates that male-headed households are more likely to participate in the potato market than female-headed households. As the qualitative findings have shown, potato is currently being cultivated mainly targeting the market. Its production may require particular resources such as land and inputs that are not easily accessed by female-headed households. Therefore, male-headed households have a higher likelihood to participate in potato market because they may be having significant access to productive farm resources compared to those headed by women. The probability of participating in the potato market reduces by 14% if the household is headed by a woman. This finding underscores results reported by Hill and Vigneri (2014) in a study that mainstreamed gendered participation in Cocoa supply chain in Ghana. In addition, Zamasiya *et al.* (2014) and Sebatta *et al*. (2014) established that male-headed households were more likely to participate in soybean and potato markets in Zimbabwe and Uganda, respectively.

For bean crop, there was no significant difference between male-headed and female-headed households. This was not expected because first, the information from FGDs showed that bean is more likely to be a woman's crop. Second, in another study done in Kenya on pigeon pea, which is also labeled as woman's crop in the research area, results showed that female-headed households

have a higher probability of participating in the output market. In the context of this study, the weak relationship between the sex of the head and market participation can be interpreted as an indicator that for both types of households, the probability to participate is more or less equal. In addition, it was noted that the finding that bean is a woman's crop was mainly applied to male-headed households in which bean and potato are gendered.

Assets and use of improved inputs

The direction of the association between landholding and market participation and the level of commercialisation was positive and significant, albeit at different levels across the three models. The coefficient for farm size was significant at 1% and 5% level for the overall and bean probit models, while it was significant at 1% level in the truncated models for the overall and potato sample. The positive relationship between landholding and market participation and commercialisation is plausible and suggests the importance of land as one of the most critical productive resources in agriculture. The estimated marginal effect indicates that an increase in landholding by one hectare increases the probability of households' market participation by around 14% among the total sample and the bean producers (Table 17). It also shows that an increase in land size enhances the intensity of market participation of around 6% among potato farmers and the combined sample. These results indicate that land is an important incentive for shifting from subsistence farming among smallholder farmers. The positive effect of landholding is attributed to the marginal effect of land on crop output. For a farming household, having a bigger land can also be a motivation to focus on farming as self-employed and investing in market-oriented production. The results emphasises the finding of earlier works by Mmbando *et al*. (2015) and Awotide *et al*. (2016), conducted in Tanzania and Nigeria, respectively. These studies established a positive and significant association between landholding and market participation and commercialisation among smallholder farmers.

The use of any of the improved inputs namely mineral fertilizers, pesticides, and improved seeds was found positive and significantly related to the likelihood to output market participation across the crops. The finding was expected as these are bought inputs and households that use them may be more likely to target profit through commercialisation. Moreover, the use of these inputs is promoted in order to improve agricultural productivity leading more surplus for market. The estimation of marginal effect showed that the use of any of these inputs could increase the probability of output market participation by around 13% (Table 17). These results are in line with

the findings by Marenya *et al*. (2017) which highlights that maize market participation has been influenced by the use of productive resources including inputs such as fertilizers and land in Ethiopia. They also reflect the effect of modern inputs uses on output commercialisation through improved agricultural productivity.

The number of transportation assets mainly, bicycle and motorbike, have been negative and significantly related to the level of commercialisation of bean farmers, but it was insignificant in the other models. This indicates that among bean farming households, as the number of transport assets increases, the quantity of sold beans tend to reduce. As reported in Table 17, the estimated effect of an additional 1 asset in the household would be 7% less on the quantity of bean to be commercialised. This finding was not expected as the means for transport are helpful in terms of carrying their produce to the market. With good access to transport facilities, farmers are expected to face lower transaction costs, which would motivate them to sell more. Thus, in the sample for bean crop, the households that possess transport means have lower intensity of output commercialisation or the transport assets are not used in bean commercialisation. In the first case, the ownership of a number of transport assets can be a sign of wealth among the farmers as poor smallholders tend to own fewer assets in general (Donovan & Poole, 2014). This implies that wealthier bean farmers have a lower level of commercialisation, which is plausible due to the food security value attached to this crop. In fact, for a traditional rural family, the absence of beans in the house is interpreted as the absence of food. Therefore, wealthier households could be keeping beans for consumption as they may have other sources of income. The fact that transport assets are not used in bean commercialisation can be possible in male-headed households where assets are mainly controlled and used by husbands. So, since bean is considered as a wives' crop, its commercialisation in most of the male-headed households is under their responsibility, and they may not know how to use the transport assets (for instance, very few women know how to ride a bicycle) or may not have the power to decide on using this asset. This corroborates with the current debates on gender inequality in control and use of households' assets (Deere *et al*., 2013; Johnson *et al*., 2016).

Ownership of a mobile phone was found significant and positively related to the degree of households' market participation in the overall sample and for each of the studied crops. This means that in households where women possess a mobile phone, the amount of bean or potato commercialised is higher compared to the others without a phone. The growing coverage of mobile

phone in Rwanda has made this tool the most important channel for information sharing. Among farmers particularly, mobile phones should be helping them to get the information on market and market price but also to network with various actors like other farmers or buyers. This may be motivating the farmers to sell more like the partial effect of having phones was found to be around 7% in the three models (Table 17). This indicates that women farmers use their phones in information search and network with other actors which in turn increase the level of output market participation among their households. A positive and significant relationship between smallholder market participation and ownership of mobile phone was established by Fan and Garcia (2018) in Peru. Tadesse and Bahiigwa (2015) also found a significant association of mobile phone use and the level of output commercialisation in Ethiopia whereas Overå (2006) highlighted the role of mobile phone in facilitating yam commercialisation in Ghana.

Table 18: Partial effects of the women and households' characteristics

		Pooled sample		Beans		Potato	
	Variables	dy/dx	Std. Err.	dy/dx	Std. Err.	dy/dx	Std. Err.
Market participation (Probit model)	Schooling years	0.017**	0.008	0.005	0.011	0.040***	0.010
	Main occupation	-0.016*	0.009	-0.010	0.014	-0.031***	0.011
	Household size	-0.021***	0.008	-0.021*	0.012	-0.025***	0.009
	Land size	0.145***	0.053	0.139**	0.069	0.053	0.061
	Use of improved inputs	0.130***	0.041	0.131**	0.056	0.136***	0.052
Intensity of participation (Truncated model)	Schooling years	0.016***	0.005	-0.003	0.007	0.018**	0.007
	Land size	0.059***	0.015	0.047	0.033	0.061***	0.017
	Transport assets	-0.029	0.026	-0.072**	0.030	-0.016	0.025
	Have mobile phone	0.072**	0.032	0.070*	0.039	0.071*	0.039

Note: *, **, and *** denote 10%, 5%, and 1% significance levels

Women's responsibility and contribution in decision making

The findings from the qualitative data revealed that in some villages, beans production is mostly under the responsibility of women whereas potato is a men's crop. The quantitative analysis revealed a negative relationship between the person who is responsible for the crop and the

probability of households' participation in the output market. Responsibility was understood as being in charge of the production, supplying most of the labour to this crop and being able to give information about the crop in the households. The base reference was a male adult who is mostly the household head (in around 80% of the cases) or any adult male living in the household. Results showed that among potato producers, the probability of market participation is likely to reduce by around 11% in households where a woman is responsible compared to where a man is responsible (Table 18). The same significant effect was also found in the overall model. For bean farmers, there was no significant effect with regard to the person in charge. However, the findings from the truncated model showed a different scenario; households, where beans production is under women's responsibility, had a lower level of market participation compared those in which the crop is managed by men. The lower level of commercialisation was also found when the comparison is made between households where the crop was managed by a man and when it was managed jointly. The same results persisted even in the pooled sample and in both cases.

These results indicate differences in market participation between farm households when the responsible person of the crop is taken into consideration. Looking at the case of potato, the probability of market participation reduces when a woman manages the crop while this has no effect once a household manages to participate. Conversely, for beans, the participation is not affected by the responsible of this crop but if the households participate, the quantity sold is less among those households in which women are responsible for the crop. The difference of the commercialised quantity was estimated to be around 17% among bean producers and 18% when the combined sample is considered. In households where both male and female adults have been responsible for bean crop, the intensity of households' commercialisation reduced by 15%. This difference could be explained by the fact that the studied crops are gendered or by other gender issues that may be existing within farm households. Farmers' participation in the output market requires enough production and this is a function of certain factors including the improved and modern inputs but also the knowledge on how to use them. Referring to the use of bought inputs, one key informant from potato farmers' cooperative emphasised on the importance of mineral fertiliser:

> *"…with the application of fertilisers, productivity could increase from 10T up to 30T/Ha for potato crop*." Representative of COAMIVU cooperative.

From the quotation above, it is clear that potato productivity is dependent on the access to and use of mineral, for example, which also need some skills on dosage, storage, or time of application. Women farmers face more limitations than men in terms of accessing the production inputs such as the fertilizers and where accessed, the awareness on the application procedures and recommendations may be correlated by gender (Doss, 2001, 2017). In the present study, the assessment of how smallholder households link with input markets showed that few women farmers interact with input suppliers compared to men from the same households. Thus for potato crop, the predicted decrease of the probability to participate can be explained by a difference in agricultural productivity which is, in turn, a result of the gender gap in terms of access to the inputs and the skills to use them. This is in line with a number of studies in Africa including Karamba and Winters (2015) and Olakonjo (2017) in Malawi and Nigeria, respectively.

In the case of beans, the possible reason for this difference in commercialisation is that the crop is mainly grown for household consumption. So within smallholder households, the decision to sell a particular quantity of beans might need a certain negotiation among the family members, mainly spouses in this study. Women who are in most of the cases, responsible for the crop possess lower bargaining power compared to men which may negatively affect the quantity the household decides to sell. In this case, the low level of market participation among the households in which women are responsible for bean crop results from unbalanced gender relations. Alternatively, the gendered perception that the woman is supposed to produce for household subsistence may be playing a role. Hence, in some households, bargaining may not even be occurring. This should be the case for households where "a woman can sell a small amount to buy like soap or salt" (FGDs, Burera). For potato, the intra-household negotiations may not affect the quantity to sell (truncated model) because the crop is comparatively more commercial oriented. In one focus group, the discussants said that "*Whatever the quantity of potato they produce, it is sold and the household remain with a small proportion for consumption*" (FGD, Burera).

Returning to how households decide on the quantity to sell, a variable on the woman participation was included in the second hurdle (truncated model). The reference was "had no input" which mean the woman in a specific household has no say on the quantity to sell. In other words, someone else, mainly a husband (in 80% of the households) or any other adult member takes the decision on how much to sell. The findings showed a negative association between the level of women's involvement in decision-making and the level of households' market

participation, indicated by the quantity sold. For potato, the households where women had the highest level of involvement (that is, had input in all of the decisions), the intensity of market participation has reduced by 13% compared to those in which women were not involved at all (Table 18). This suggests that in these households, women have influenced the decision towards selling less quantity of potato and maybe keeping more for households' consumption. This is in line with literature on women empowerment and altruism. Where women have the power to make choice, there more chance for the household being food secure (Bhandari, 2017). Women are also (perceived) as being more concerned about households' food security than men (Chant, 2014).

Table 19: Partial effect of women's participation in agricultural decisions

		Pooled sample		Beans		Potato	
Model	Variable	dy/dx	Std. Err.	dy/dx	Std. Err.	dy/dx	Std. Err.
Market participation	*Responsible person(Base: Adult man)*						
	Woman farmer	-0.109**	0.056	0.005	0.068	-0.300**	0.134
Level of market participation	*Responsible person (Base: Adult man)*						
	Woman farmer	-0.183***	0.034	-0.167***	0.053	0.011	0.098
	Woman with other members	-0.017	0.035	-0.144***	0.054	0.014	0.038
	Decisions on the quantity (Base=No input						
	Input into all decisions	-0.092*	0.055	0.066	0.070	-0.135**	0.063

Note: *, **, and *** denote 10%, 5%, and 1% significance levels

Institutional and access factors

Rural household participation in social groups has been widely cited as essential to overcoming market failure that delinks farmers from agricultural markets. Results from the double hurdle models strongly validate this argument. Women's membership in groups was strongly positive and significant, indicating its potential role in increasing the probability of their households' participation in bean and potato markets. It was also found positively and significantly related to the extent of households' participation. The explanation for this is that group membership is a unique form of social participation that allows the fast exchange of market information as well as

the new technologies and innovation. Furthermore, group membership possibly provided an important pathway of linking farmers to bean and potato markets ceteris paribus. The economic feature of social capital is clearly manifested in this finding. Group membership provided a pathway to reducing transaction costs associated with individual marketing, particularly for the potato crop. The estimated effects of group membership for women farmers was 30% and 39% increase on the likelihood of households' participation in the bean and potato market, respectively. The level of households' participation was also estimated to increase the level of commercialisation by 8% and 7% in the overall sample and the bean producers, respectively (Table 19). These results reiterate the findings reported by Egbetokun *et al*. (2017) and Marenya *et al*. (2017), who found that group membership enabled market participation among maize farmers in Nigeria and Ethiopia, respectively.

Agricultural training was positive and significantly with the extent of market participation among bean producing households. This suggests that as woman farmers get training on agricultural practice, the quantity of beans that is commercialised by her household increase. This relationship can be explained by the fact that women's contribution in bean production is important and their training can have a positive effect on bean production. Hence, access to agricultural knowledge among women farmers improves their farm productivity and their households' market participation. The findings are consistent with Barham and Chitemi (2009) who found that training improved farmers' capacity to negotiate the price and to reorient their production towards more profitable markets.

As expected, market price positively influenced the extent of households' participation in the bean market. Although insignificant, the coefficient of market prices had an unexpected sign on the overall and potato model estimates. The positive and significant result on the market price for bean regression estimates implies that as the market price of bean increases, farmers are more likely to increase the quantities of beans supplied to the market. Comparatively bean prices for the previous season and current season possibly provided an incentive that signaled farmers to increase quantities supplied to the market associated with the volume of sales. Sharma (2015), also showed that an increase in price risk was negatively associated with Indian milk farmers' market participation. The price risk was attributed to inter-seasonal prices variation on which farmers base their market participation decisions.

In the same way, agricultural income from the previous season was positively and significantly associated with the level of commercialisation for both crops. The estimated marginal effect showed that a 1% increase of agricultural income would increase the market participation level by around 1% in the next season (Table 19). This indicates that agricultural income is a key capital that helps smallholder households to invest in farming. It is also consistent with the number of quotations from the FGDs in which farmers said that "if they fail to sell their production, they fail to buy agriculture input" for the next season. This is also an indicator that farmers rely more on their previous agricultural income in their struggle to transformed agriculture, which may be a justification of the non-significance of credit. This finding is in line with Okezie *et al*. (2012) who suggested that agricultural commercialisation leads to market orientation through a progressive adoption of modern purchased inputs. Similarly, Adjognon *et al*. (2017) have found a positive relationship between crop sales and the decision to buy fertilizers in Nigeria.

Farmer proximity to all-weather roads was negative and significant in influencing market participation among bean and potato farmers. This implies that the farther the farms are away from a road that can be used throughout the year, the lesser the probability of the smallholder households' participation in the output market. The estimation of the marginal effect revealed that when a household is located at more than 60 min of walking from the usable road, the likelihood to participate was reduced by 13% and 9% for beans and potato, respectively (Table 19). For both crops, the proximity to the road had no significant effect on the level of households' market participation. This result is vital to illustrating infrastructural factors that hinder farmer participation in the output market as it shows that failure to participate can be household-specific. In this context, distance to the road possibly reduced the probability of households' participation by limiting their access to services and information. Actually, service providers tend to be rare in remote areas where these households may be located. Distance to the road possibly increased the marginal cost of market participation, which may constitute a disincentive to participate among the households. This confirms the findings from focus groups in which some discussants complained about the cost of inputs due to the expensive transport and bad roads. Households in remote areas are victims of high transaction costs, lower prices and fewer buyers, leading to further lower commercialisation (Chamberlin & Jayne, 2013). The findings are consistent with Ali *et al*. (2017) who also found that access to the road network was a prerequisite for cotton farmers' market participation in Pakistan.

The proximity was estimated based on the time used from the main road nearest the household to the border of Cyanika, in public transport. As expected, the proximity to the Ugandan border negatively and significantly affected the market participation of bean. This means that the households which use more than 60 minutes traveling to reach the border have less likelihood of market participation, ceteris paribus (Table 19). This implies that the distance to this border reduces the likelihood of bean farmers' participation and the extent of participation in the market. This suggests a possibility of cross-border commercialisation of beans and it is consistent with the qualitative data in which key informant said that they sometimes sell to Ugandan markets. It could be that the market gives a good price which may motivate bean farmers. Thus if the households is located farther from the border, then it may be optimal for the farming household to produce bean for self-consumption rather than incur the transaction costs associated with longer distances to the competitive foreign market. Second, distance to the border may deter market participation and extent of participation when households determine that the opportunity cost (transaction costs) associated with searching for alternative domestic markets is relatively high. Put together, the fixed transaction costs to the border and the opportunity cost involved in searching for an alternative domestic market reduces profitability, negating households' participation in bean market.

The negative and significant association of time used to reach the border and road are important indicators of market failure that limits farmer participation in output markets in Rwanda. These factors might have increased the width of price bands, making participation in bean and potato markets less remunerative. Farmers have to confront the reality of imperfect output markets that result from high transaction costs leading to low profit margins. Consequently, production decisions become inseparable from consumptions decision which limits market participation. These results are consistent with Gani and Adeoti (2011) and Gebremedhin *et al*. (2009), in their respective studies on smallholder marker participation in Nigeria and Ethiopia.

Table 20: Partial effects of institutional factors

		Overall		Beans		Potato	
Model	Variable	dy/dx	Std. Err.	dy/dx	Std. Err.	dy/dx	Std. Err.
Market participation (Probit model)	Group membership	0.313***	0.029	0.302***	0.047	0.247***	0.038
	Road (1= walking time>60min)	-0.071	0.045	-0.135*	0.070	-0.092*	0.049
	Border (1= travel time>60min)	-0.165***	0.058	-0.322***	0.105	-0.057	0.062
	Market price	0.000	0.000	0.001***	0.000	0.000	0.000
	Agriculture training	0.080**	0.035	0.160***	0.049	0.016	0.041
Level of participation (Truncated model)	Group membership	0.082**	0.033	0.071*	0.033	0.045	0.042
	Agricultural income	0.012***	0.003	0.010**	0.005	0.009**	0.004

Note: *, **, and *** denote 10%, 5%, and 1% significance levels

4.5. Estimating the influence of household market participation on food access

4.5.1. Ordered Logit model diagnostics

The model fitness tests indicated that ordered Logit model fit the data well, justifying its application for the analysis of influence of market participation on household food access. The Wald χ^2= 33, p= 0.0000 and pseudo coefficient of determination = 0.2562 are statistically significant for the bean equation. The Wald χ^2= 74.65, p= 0.0000 and the pseudo coefficient of determination = 0.2373 for the potato equation are also statistically significant. These imply that ordered Logit model fits data well for the two models. The Brant test for parallel-lines assumption

was statistically insignificant, implying that the assumption was not violated. Therefore, fitting separate ordered Logit models for the two crops was justified.

4.5.2. Results from the models for bean and potato farming households

Table 20 presents results from ordered Logit model for bean farming households. The second column of the table provides the coefficients while the third column throughout six provides marginal effects. The results of the ordered Logit models for bean indicated that commercialisation level, land size, having made some savings, total income, women's input in income decisions, and input in quantity sold decisions have a statistically significant influence on food access. As given in Table 20, the commercialisation level has a potential influence on households' food access. Among bean producers, the results indicate that both levels of participation in the output market were positively and significantly associated with the probability of being food secure at a 5% significance level.

When looking at the effect of commercialisation in each food access category, results show that households in severely food insecure category risk to worsen their situation regardless of their level of market participation. In this category, households that sell less than 50% of bean output had a 10.9% chance of being less food secure compared to those which have not sold their bean output (non-participating). In contrary, households in the category of mildly food insecure and food secure that sold less than 50% of bean produced have got a 2.1% and 8.6% chance of being in food secure category and being more food secure, respectively, compared to those households that have not participated in the bean output market (Table 20). Again, those who sold 50% or more of bean output were 16.5% less likely to be food secure compared to non-participating ones in the category of severely food insecure households. In addition, households in mildly and food secure categories had respectively 2.8% and 14.1% chances of improving their food access security by selling 50% or more of beans, compared to those which did not participate in the bean market (Table 20).

The land size owned by bean farmers also influences household food access status. Total land size owned was positively and significantly associated with the probability of being in a higher level of food security status at 1% significance level. The marginal effects indicate a negative influence of land size on the probability of being food secure among those in severely food insecure category and a positive influence on those being in mildly food insecure or food secure respectively. The estimation of marginal effects in different categories of food access security

showed more details on the relationship between land size and food access security. Among households with a severely food insecurity status, results in Table 20 show that an increase of 1 of land size by 1 hectare reduced the probability of being food secure by about 20.8%. However, this increases the likelihood of being food secure by 3.9%, and 16.5%, respectively for the households in mildly food insecure and food secure.

Food access status is also positively and significantly influenced by farmers' participation in group savings at 1% significance level for the bean model. In other words, farmers who have managed to make savings are more likely to be food secure compared to those with no savings. The negative marginal effects implied negative influence of having made some savings among the households in severely food insecure status (15.7%) and positive influence of saving in the mildly food insecure (3.0%) and food secure (12.4%) households. In bean model, the total income was also positively related to food access security for the households with severely food insecure status. This means that households with higher income have more likelihood to improve their food access status from being severely insecure to being moderately food insecure. However, income had a negative relationship with food access in the households that belong to the two highest levels of access security.

The extent of women's participation in agricultural income decisions was negatively related to food access in mildly food secure and food secure categories while positive in severely food insecure households. This means that among severely food insecure bean producing households, those in which women contribute in all decisions on income have 16.6% likelihood of improving their food access status to moderately food insecure. In contrary, for those in the two highest levels of food access status, women' inputs in all income decisions reduce households' chances (by 3% and 12%) of being secure in terms of food access.

Table 21: Effect of bean output market participation on household food access

	Model	Severely food insecure	Moderately food insecure	Mildly food insecure	Food secure
Variable	Coeff.	dy/dx	dy/dx	dy/dx	dy/dx
Commercialisation level					
Sold less than 50%	0.769**	-0.109*	0.002	0.021**	0.086*
Sold 50% or more	1.187**	-0.165**	-0.005	0.028**	0.141*
Age of the woman	-0.004	0.001	0.000	0.000	0.000
Gender of household head	0.934	-0.128	0.002	0.024	0.102
Education level (year)	0.098	-0.013	0.000	0.003	0.011
Household size	-0.008	0.001	0.000	0.000	-0.001
Land size	1.511***	-0.208***	0.003	0.039**	0.165***
Market price	0.002	0.000	0.000	0.000	0.000
Self-employment	0.639	-0.088	0.001	0.017	0.070
Make savings	1.139***	-0.157***	0.002	0.030**	0.124***
Market	-0.404	0.056	-0.001	-0.011	-0.044
Climate hazard	0.190	-0.026	0.000	0.005	0.021
Illness shock	-0.509	0.070	-0.001	-0.013	-0.056
Total income	-0.162***	0.022***	0.000	-0.004***	-0.018***
Wald χ^2 = 133 p-Value= 0.0000; Pseudo R^2 = 0.256					

Table 22: Effect of bean output market participation on household food access-Continuation-

Variable	Model Coeff.	Severely food insecure dy/dx	Moderately food insecure dy/dx	Mildly food insecure dy/dx	Food secure dy/dx
Decisions on income					
Input into some decision	-1.059	0.155	-0.011	-0.030	-0.114
Input into most/all decision	-1.129*	0.166*	-0.013	-0.033*	-0.120**
Decisions on quantity sold					
Input into some decision	0.755	-0.107	0.020	0.015	0.072
Input into most/all decision	3.075***	-0.408***	0.004	0.042***	0.363***
Wald $\chi^2 = 133$ p-Value= 0.0000; Pseudo $R^2 = 0.256$					

In relation to decisions on the quantity of beans to be commercialised, women's participation in all decisions had a negative influence on food access among severe food insecure households (Table 20). Whereas, households that are already in mildly food insecure and food secure groups had a higher likelihood of being food secure when women participate in all decisions on the quantity of beans to be sold (4.2% and 36.3% respectively).

Turning to the potato farming households, the results presented in Table 21 show that compare the non-participating households, those who participated in output market by selling over 50% of output were 22.5% less likely to be food secure when they are in severely food insecure category. Those in moderately food insecure, mildly food insecure, and food secure categories respectively had 5.2%, 4.5%, and 12.8% more likelihood to be in better food access status compared to non-participating households in the same categories. The education level of the women significantly (at the 10% level) influenced food access status in potato farming households. Increasing the level of education of women by 1 year reduced the likelihood of being food secure in severe food insecurity by 1.9 %. In addition, increasing the education level of a woman farmer by 1 year resulted in 0.4%, 0.03%, and 1.2% likelihood of shifting from moderate food access insecurity, mild food access insecurity, and secured food access towards a better position of food access status (Table 21). The marginal effect of land size was also significantly associated with household food access security in the estimated model for potato farmers. Increasing land size by 1 hectare reduced the probability of shifting to better food access status within severe food-insecure households by about 22.2%, but it increased the possibility of becoming food secure for moderate food security, mild food insecurity, and food security by 4.4%, 3.9%, and 13.9%, respectively. Making savings was positively and significantly associated with household food security among potato producing households. Those who have saved some money were 14.1% less likely to be severely food insecure, 2.8% more likely to be moderately food insecure, 2.5% more likely to be mildly food insecure, and 8.8% more likely to be food secure relative to households that had made no savings (Table 21). Household income negatively and significantly influenced food access status at 1% significance level for potato farmers. This implies that an increase in total income increases the probability of being food insecure. Marginal effects results indicate that, as total income increases by one unit, there is a 0.7%, 0.6% and 2.1% probabilities of being less food secure among the households in the moderate food insecure, mildly food insecure and food secure categories, respectively. However, for the households in the severe food insecure group, an increase in

household income by one unit resulted in 3.3% chances of improving their food access, shifting to the next better status to food secure category.

Within severe food insecure households, food access was also negatively influenced by women input in income decisions (Table 21). This implies that in this category, households that engage women farmers into almost all income decisions are less likely (by 12.1%) to be food secure compared to those who do not engage them in income decisions. However, in households in moderately, mildly and food secure groups, the marginal effects indicate a positive influence of women' engagement in almost all income decisions on the probability of being food secure by respectively 2.4%, 2.3%, and 7.4%. On the other hand, women participation in almost all decisions on quantity to be sold in the market, reduced chances of having food access among the severely food insecure households by 38.3% and increased the probability of being food secure in the mildly food insecure and food secure households by about 7.6% and 33.6%, respectively for potato farmers (Table 21).

Table 23: Effect of output market participation on food access among potato households

	Model	Severely food insecure	Moderately food insecure	Mildly food insecure	Food secure
Variable	Coef.	dy/dx	dy/dx	dy/dx	dy/dx
Commercialisation level					
Sold less than 50%	0.524	-0.083	0.026	0.017	0.040
Sold 50% or more	1.396***	-0.225***	0.052***	0.045***	0.128***
Age of the woman	0.003	0.000	0.000	0.000	0.000
Gender of household head	0.041	-0.007	0.001	0.001	0.004
Education level (years)	0.122*	-0.019*	0.004*	0.003*	0.012*
Household size	0.014	-0.002	0.000	0.000	0.001
Land size	1.401***	-0.222***	0.044***	0.039***	0.139***
Market price	0.000	0.000	0.000	0.000	0.000
Self-employment	-0.589	0.093	-0.018	-0.017	-0.058
Making savings	0.886**	-0.141**	0.028**	0.025**	0.088**
Market	0.826**	-0.131**	0.026*	0.023*	0.082**
Climate hazard	-0.124	0.020	-0.004	-0.003	-0.012
Illness shock	-0.009	0.001	0.000	0.000	-0.001
Total income	-0.209***	0.033***	-0.007***	-0.006***	-0.021***

Table 21: Effect of potato market participation on household food Access-Continuation

	Model	Severely food insecure	Moderately food insecure	Mildly food insecure	Food secure
Variable	Coef.	dy/dx	dy/dx	dy/dx	dy/dx
Decisions on income					
Input into some decision	1.124**	-0.177**	0.029**	0.033**	0.115*
Input into most/all decision	0.767**	-0.121**	0.024*	0.023*	0.074*
Decisions on quantity sold					
Input into some decision	-0.810	0.141	-0.060	-0.030	-0.051
Input into most/all decision	2.503***	-0.383***	-0.029	0.076***	0.336***

Observations: 178; Wald χ^2 = 74.65 p= 0.0000; Pseudo R^2 = 0.2373

*, **, ***, denote significance at 10%, 5%, and 1% levels, respectively

With some few exceptions, the influence of studied factors on households' food access status tends to be the same for both bean and potato producing households. Most of all factors considered were negatively related to food access within the severely food insecure households. The exception was only found when estimating the effect of income on food access for both crops and women's participation in income decisions for bean crop. The results show that among the severely food insecure households, increasing their income would increase their likelihood to be in a better status in terms of food access and therefore improve their food security. However, this income should be off-farm since their participation to market showed a negative effect on their food access status. In other categories of food access security, the negative relationship between income and food access can be explained by the fact that income and expenses on food item may not be growing exponentially. Although these results are against the prior expectation, it could be attributed to diversion of income to other investments decisions by households. Hence as the income grows, the expenses on food does not necessarily grow, contrary to the severely food insecure households who could be spending their income on food. This confirms the findings by Fan *et al*. (2013) that smallholders are not homogeneous and not all of them have potential benefit in agricultural commercialisation. It is also consistent with Banerjee and Duflo (2006) who found that poor people spend most of their income on food items, in their study on developing countries. In the present study, households in severely food insecure group could be the poorest of the studied smallholder households.

While selling bean or potato output was found to worsen food security status within the severely food insecure households, it was positively related to food access in other groups of farmers for both crops. The possible explanation of the positive effect of commercialisation on food access could be that market participation significantly increased the income of smallholder farmers through better market prices. Better prices possibly increased farm income, thereby contributing positively to household food access. These results are in line with the findings by Muriithi and Matz (2015), Muricho (2015) and Camara, (2017) that supports positive income effects of cereal commercialisation at the household level in developing countries. These authors reaffirmed that participation in output markets is a means to improve smallholders' livelihoods through raising income, and thereby a means to increased food security. Among the severely food insecure, the explanation of the negative effect of commercialisation could be that households in this category, households may have an already small quantity of production and therefore, remain with an

insufficient quantity of produce for home consumption. This corroborates with the warning by Fan *et al*. (2013) that some smallholder farmers sell their produce and find themselves food insecure.

The positive association of land size and food access security is underlined by its statistical significance in the models for bean and potato farming households. These imply that the larger the land size the higher the likelihood of being food secure. This could be attributed to the agricultural production and income, which increases with the increase in land sizes. This result is also consistent with the findings of Khonje *et al.* (2015) who found that large land sizes enhance adoption of agricultural intensification practices which increases farm productivity and crop income hence reduces poverty and improves food security. The explanation of the negative relationship between land and food access among households in severely food insecure group could be that farmers in this group may be having limited capacity to improve the productivity of their farms efficiently.

The positive influence of women's education on households' food access was expected since education generates knowledge and enhances farmers' capacity to innovate to improve their welfare. It also increases the capacity of farmers to cope with various shocks that may negatively affect households' food security. As women are traditionally concerned with food security, those who have more schooling years probably have more access to adequate information on food security and are more enthusiastic in implementing strategies that influence household food access. Bashir *et al*. (2013) reported similar results in a study that was conducted in Pakistan.

Households that have made savings also had a higher chance to be in better food access status, except those already in a severely food insecure category. The positive association of saving and household food access is attributable to the fact that households that make savings tend to be financially accountable, hence ensure that their savings are used appropriately especially on improving food security status. Making some savings may also help in making an informed farm or off-farm investment decisions which translate to higher gross income, thereby contributing to food security. Rasoaisi and Kalebe (2015) and Mitchell and Lusardi (2015) reported that high financial knowledge allows an individual to make informed and effective financial decisions especially regarding better investment decision which translate to higher income and food security levels. The negative influence of savings on food access among the severely food insecure households is against the prior expectation but it could be that savings in these households could be made for other purposes than for buying food for the household.

The estimated effect of women's participation in income decisions had opposite directions for bean and potato crops. Among the severely food insecure households, women' input in most of the household income was positive for bean farmers and negative for potato farmers. This implies that in the severely food insecure bean farmers, the participation of women in most of the income decision is more likely to improve household food access. So, in this category, households that engage women in their income decisions are more likely to shift to better food access status compared to those who do not engage them in any income decisions. In contrary to potato producers, severely food insecure households increase their likelihood to remain in their status when they involve women in income decisions. In other categories of food access levels, women's participation in all income decisions would increase the likelihood of becoming food secure for potato producers and for bean farmers, it would reduce the chance of remaining food secure.

In the cases where women's participation in income decisions was negatively associated with food access, this result was not expected. Actually, the conventional knowledge is that women decide in favour of food security of their households and the households that engage them more in income decisions were expected to have more access to food. In the literature, women are acknowledged to spend on food items when they have more control over household income (Njuki *et al*., 2011). Findings from Bangladesh also showed a positive influence of women's participation in agricultural decisions, including those related to income, on food availability and dietary variability among studied households (Sraboni *et al*., 2014). In the present study, the findings on women's participation in income decisions could be interpreted by first highlighting that in most of households, women are more concerned of their households' needs including those related to food and non-food items. This is particularly caused by their gender triple role in productive, reproductive and social spheres and it certainly affects their decisions on income allocation (Grassi, Landberg, & Huyer, 2015; Lyon, Mutersbaugh, & Worthen, 2017). Second, it would be noteworthy recalling that in this study context, beans farming is considered more as a woman's crop and it is mainly for home consumption while potato is more market-oriented and mostly managed by men.

For bean crop, it could be that women in severely food insecure households have less flexibility in allocating their income and could mainly be spending it on food for their households. This implies that in severely food insecure groups, the income that is earned by bean producing households could be only allocated to food purchase and therefore had a positive influence on food

access. In contrary, women in mildly food insecure and food secure households could be enjoying more budget flexibility and therefore, influence spending agricultural income on non-food items. In some cases, the income from beans would be used to buy small things like soap or salt while in others, agricultural income would be given to the wife as a reward for her contribution in the field (Ingabire *et al*., 2018). In one of the discussions, it was clear that in some families, the income from beans though small would be used on non-food items when the husband accepts this. This is like in the following quotation which shows that a proportion of income would be used to buy wives' personal items such as clothes:

> "*When a husband is not too complicated, and he sees you harvest like those 30 kilograms to feed children, he can allow his wife to sell some 5 kilograms and buy a skirt*".

Among potato producing households, the negative association between women's participation in income decisions in severely food insecure group could be explained by the fact that potato may be the primary source of income for them and it may not be sufficient. So when women are highly engaged in decisions over this income, they fail to allocate adequate amount about food given the other households' and individual non-food needs, which worsen their food access status. For the other group of potato producing households, the positive association of women's participation in income decision and food access is in line with the literature (Amugsi *et al*, 2016; Shroff *et al*., 2011). It also implies that for a more market-oriented crop like potato, women's bargaining power on agricultural income allocation would improve food security at the farm household level.

In relation with decisions on the output quantity to be sold, the bean and potato households that engage women in most or all decisions were more likely to improve their food access status relative to those which does not. This confirms that women bargain in favour of food security and in market participating households, they could influence in such a way that households remain with sufficient quantity for consumption. Alternatively, they could influence on taking a specific quantity to the market when the price is good and therefore get better income to be further used on food. This is in line with studies by Sharaunga *et al*. (2016) and Sraboni *et al*. (2014) who established a positive association between women's participation in agricultural decisions and food households' food security.

4.5.3. Results for the pooled sample using Generalised Logit model

The Brant test for parallel-lines assumption (Appendix 6) was statistically significant for the pooled sample, implying that the assumption was violated. Therefore, fitting a generalised ordered Logit model for the pooled sample was justified. Table 22 presents generalized ordered Logit estimates of the effect of market participation on household self-reported food access status. The model's Wald of 242.14 is statistically significant at 1% level. This implies that the model fits the data well. The explanatory power of the model is also significant. There were eight, nine, and six significant variables for severe food insecurity, moderate food insecurity, and mild food insecurity statuses. These results are interpreted in the following paragraphs. The coefficient on each category contrasts the category of a higher category of food access security.

Higher level of market participation had a positive and statistically significant coefficient for severely and moderately food insecure households. This implies that households that sold more than 50% of bean and potato were more likely to be in higher categories of food access security compared to households that never participated in the output market (Table 22). This result was expected considering the welfare effects that accompany increased commercialisation. This also underlines the importance of agricultural commercialisation as an essential pathway to food security. Improvement in food access status could have been twofold; one emanating from improved productivity and the other from increased farm income. Besides positively impacting on agricultural productivity through increased market opportunities and higher agricultural investment, commercialisation possibly led to additional farm income which was instrumental in improving household' access to food through purchases. Asfaw *et al*. (2012) reported similar results and argued that market participation increased the likelihood of higher food security status among smallholder farmers in Kenya. In contrast, Oluwatayo and Rachoene (2017) found that commercialisation reduced chances of food security among smallholder farming households in South Africa.

The level of education of a woman farmer in the household was positive and statistically significant across the three food access categories (Table 22). This implies that the education level of a woman farmer increased the likelihood of her household being in higher food access status. Because the model contrasts each level of security to the next higher level, the finding suggests that education enables a household to become secure in terms of food access. The more educated the woman was, the higher the level of food access in her households. Education is a vital human

capital that probably empowered women by increasing their innovativeness as well as the quality of their contribution which played a role in enhancing households' food access. Education created woman awareness and knowledge of strategies for enhancing household food security. This finding is consistent with the studies conducted by Bashir *et al*. (2013) and Kassie *et al*. (2015) in Pakistan and Malawi, respectively.

Household participation in savings was positive and statistically associated with the possibility of households being in higher categories of food access (Table 22). The result suggests that households which made some savings are more likely to be more food secure compared to households with no savings. This finding highlights a possible connection between savings and food security. This connection may be in two ways, first in reducing the worry about whether the household will have food or not, which increases the chance for this household to appear in more food access secure category. Second, putting some money aside for saving could have helped reduce household food access insecurity through women's increased capacity to cope with food shortage shocks and possibly improved financial skills. By savings, women who usually give priority to food security have been able to purchase food when necessary. Finally, the acquisition of savings or financial management ability allows households to give priority to food security hence helping reduce the risk of food access insecurity. Ariful *et al*. (2017), in an almost similar study, found that access to financial information and services had positive food insecurity reducing impact in Bangladesh.

Table 24: Generalized ordered Logit estimates of effect of market participation on food access

	Severely food insecure	Moderately food insecure	Mildly food insecure
	Coeff.	Coeff.	Coeff.
Commercialisation			
Sold less than 50%	0.304	0.246	0.433
	(0.424)	(0.408)	(0.560)
Sold 50% or more	1.151***	0.873**	0.055
	(0.385)	(0.401)	(0.508)
Age of the woman	0.006	-0.022**	0.000
	(0.011)	(0.011)	(0.014)
Gender of the household head	0.703	0.909***	-0.096
	(0.442)	(0.607)	(0.685)
Education level of the woman in years	0.139**	0.004***	0.226***
	(0.057)	(0.056)	(0.087)
Household size	-0.062	0.211***	-0.103
	(0.078)	(0.064)	(0.108)
Land size	1.690***	1.690	0.264
	(0.460)	(0.419)	(0.276)
Market price	0.006*	0.010	-0.002
	(0.004)	(0.003)	(0.004)
Self-employed	-0.783	-0.679	1.172*
	(0.690)	(0.612)	(0.601)
Making savings	1.354***	0.981***	0.961**
	(0.306)	(0.323)	(0.456)
Market	0.353	0.310	-0.085
	(0.318)	(0.312)	(0.454)

Table 22: Generalized ordered Logit estimates of effect of market participation on food access – Continuation

	Severely food insecure	Moderately food insecure	Mildly food insecure
Variable	Coeff.	Coeff.	Coeff.
Climate hazard	-0.308	0.487	0.603
	(0.568)	(0.669)	(0.550)
Illness shock	-0.694*	-0.026	-0.014
	(0.370)	(0.384)	(0.503)
Total income	-0.236***	-0.172***	-0.083**
	(0.041)	(0.032)	(0.036)
Input in income decisions			
Input into some decision	-0.582	0.574	2.965***
	(0.598)	(0.482)	(0.734)
Input into most/all decision	-0.694*	0.219	2.857***
	(0.382)	(0.441)	(0.522)
Input in quantity sold decisions			
Input into some decision	0.012	-1.541***	0.618
	(0.477)	(0.483)	(1.129)
Input into most/all decision	4.063***	1.580***	0.442
	(0.549)	(0.507)	(0.524)
Constant	-2.319*	-5.465***	-2.900*
	(1.339)	(1.736)	(1.488)

Observations: 389; Wald χ^2 = 242.14 p= 0.0000

Note: Standard errors are given in parenthesis

*, **, ***, denote significance at 10%, 5%, and 1% levels, respectively

Age of the woman was negatively and significantly associated with moderately food insecure households (Table 22). This means that the age of a woman increased the likelihood of households with moderate food access status to fall into the category of severely food insecure. Older women were probably less innovative in seeking information and/or learning strategies for improving household food security. Also, there is a possibility that the economic contribution, mainly through agricultural labour contribution of women declined with age. Hence, a woman became less contributing due to their old age, resulting in a higher likelihood of households remaining moderately or severely insecure in food access. Similarly, Mango *et al*. (2014) and Yahaya *et al*. (2018) found that age was negatively associated with food security in Zimbabwe and rural Northwestern Ghana, respectively. Oluwatayo and Ojo (2019) also found that Nigerian households headed by elderly people were likely to be food insecure compared to their younger counterparts.

The relationship between gender of the household head and moderate food access insecurity was positive and strongly significant (Table 22). This shows that households in moderately food access insecure under female-headship have a higher likelihood to shift to mild food insecurity relative to those headed by male farmers. This may indicate that women are food security-oriented and are more interested in mobilising farm and off-farm resources for the improvement of household food situations. Moreover, women possibly have better food management techniques that help secure household access to and availability of food. Mason *et al*. (2017) found contradictory results in Tanzania when they reported that female-headed households were more likely to be food insecure compared male-headed households because of low access to resources by women.

Household size was positive and significantly related to the possibility of moderately food insecure households becoming mildly food secure (Table 22). In the context of this study, the finding could suggest that large-sized households have adequate human capital that is available for productive agricultural and non-agricultural activities. The household may have been mainly composed of economically active persons who contributed labour to farm activities which resulted in high productivity. More so, larger households possibly committed labour to diverse off-farm activities for more income. High agricultural productivity and participation in off-farm activities may have resulted in improved household access to food. This finding supports earlier results by Amwata *et al*. (2016) in Kajiado and Makueni counties in Kenya. However, the result contradicts those by Gebre (2012), Bashir *et al*. (2013), and Omotayo *et al*. (2018), who indicate that household size was negatively associated with household food security in Ethiopia, Pakistan, and South West Nigeria, respectively.

The relationship between land size and severe food access insecurity status is positive and significant. This implies that large land sizes make it more likely for households to be in a higher category of household food access security than in severely food insecure status. This finding is plausible because of economies of scale that are connected with large land sizes. Furthermore, large farms possibly allowed farmers to diversify crop production or to practice integrated agricultural production which, in turn, resulted in increased food production and income. These could have contributed to improved households' food access. This result is in line with previous studies (Joshi & Joshi, 2017; Kakota *et al*., 2015; Tefera & Tefera, 2014).

Illness of any household member was negatively associated with severe food insecurity status. This implies that illness shock increased the likelihood of households being severely food insecure. One of the possible explanations to this is that household with a high frequency of illness of its member possibly diverted income that could have been used for food acquisition to medical services. Alternatively, a household may have sold food to meet health and medical expenses. These could have reduced the progress of the household towards higher food access status. The relationship between illness and food access could also be attributed to the effect of illness on the productivity of household members especially in the provision of agricultural and non-agriculture labour. This could have lowered agricultural production and income from off-farm sources, resulting in severe food access insecurity. Studies that were conducted in Lebanon and rural Pakistan have reported similar results (Ghattas *et al*., 2015; Zhou *et al*., 2017).

The coefficient for total income was negative and statistically significant across the three food security statuses (Table 22). This suggests that income reduces the probability of households being in higher categories of food security than their current statuses. In other words, income increased the probability of households being in lower categories of food security. This finding is unexpected because a higher income is expected to increase household access to food, thereby contributing to improved food security status. The possible explanation for this unexpected relationship is that households possibly saved in the current period for the purpose of increasing household consumption and welfare in the future. This may have resulted in a negative perception of household food access in the current period. In addition, the households possibly allocated the income on alternative household activities that reduced household access to food items. Another possible explanation is the households suffered economic shocks that deviated income away from food consumption. This finding contrasts results reported by Sibhatu and Qaim, (2017) and Tiwasing *et al*. (2018) who found that off-

farm income played a significant role in improving diets and nutrition of rural smallholder farming households in Ethiopia and Thailand, respectively.

This study also estimated the effect of women's participation in households' decision making on food access. Women participation in household and agricultural decision making are mostly taken as a proxy for women empowerment (Alkire *et al*., 2013). In this context, the effect of women's participation in decision making on household food access is mixed. Whereas women input into some income decisions and input into almost all decision were positive and statistically significant with the probability of mildly food access insecure to become food access secure, they were negatively associated with the likelihood of households remaining in severe food access status relative to women with no input in income decision (Table 22). In regards with decisions on the quantity of farm output sold, women's input in almost all decisions were positively associated with the probability of households being mildly food insecure and food secure for households who were severely and moderately food insecure (Table 22).

In contrast, input in some marketing decisions was negatively associated with the probability of moderately food insecure households becoming either mild food access secure. This finding suggests that higher level of women's participation in households' decisions have a potential of contributing to the alleviation of food insecurity. Women empowerment in decision making builds their economic and social potential, enabling them to reach their full socio-economic potential. This allows them to positively contribute to challenges that face rural households such as food insecurity. Sharaunga *et al*. (2016), in a study conducted in South Africa, reported that households headed by economically and psychological empowered women were likely to be food secure.

4.6. Effect of household market participation on on-farm employment creation

4.6.1. Model diagnostics

The Inverse Probability Weighting Estimator with Regression Adjustment (IPWRA) has two fundamental assumptions that have to be satisfied. The first assumption is the overlap assumption. The overlap assumption refers to each individual in the sample having a positive probability of receiving a specific level of treatment. The overlap assumption is satisfied when there is evidence that there is a chance of observations in both the intervention and the control groups at each combination of covariate values. This assumption is a measure for the ability of the model to account for unobserved outcomes. The overlap assumption is tested by plotting

the estimated density of the overlaps, and the assumption is violated when there is relatively little mass in the region in which the treatment and control groups overlap (Busso *et al*., 2014).

The second assumption is the balance of covariates assumption. In experimental study designs, covariates are balanced because assignment into an intervention or control group is independent of the covariates. However, in observational data, covariates have to be balanced because assignment into an intervention or control group is influenced by a set of covariates that also affect the outcome (Austin, 2011; Imai & Ratkovic, 2014; Guo & Fraser, 2015). In the IPWRA estimation, covariates are balanced by weighting observational data in order to make the outcome and treatment to be conditionally independent. Hence, it was cardinal to test how well the IPRWA was specified by focusing on how it balanced the covariates. Therefore, over-identification tests for covariate balance were performed to check the specification of the IPWRA.

Overall model diagnostics

The predicted probabilities that a market participating household is not assigned to the marketing intervention has most of its density mass near 0. The estimated density of the predicted probabilities that a non-market participating household is not assigned to the marketing intervention has most of its mass near 1. However, there is relatively a significant mass in the region in which the estimates of the density of the predicted probabilities overlap. Therefore, there was no clear evidence that IPWRA violates the overlap assumption.

The result of over-identification test for covariate balance for full model is presented in Appendix 8.1. The chi-squared test for balance statistics (χ^2=4.35128; p=0.9991) is statistically insignificant at 5% significance level (Appendix 1). Thus, the null hypothesis that IPRWA balances the covariates is not rejected. Therefore, it can be concluded that IPWRA is well specified and outcomes estimates are independent of the interventions model.

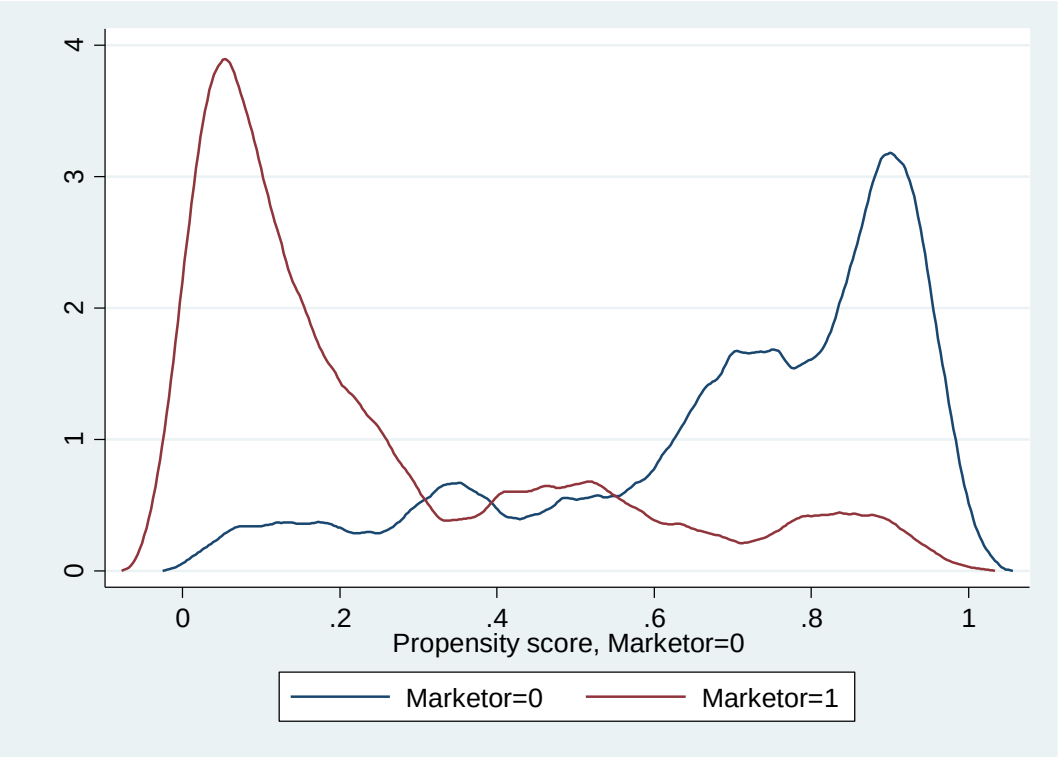

Figure 10. Estimated density of the predicted probability for pooled sample

Bean model diagnostics

Figure 11 displays estimated density of predicted probabilities that a bean market non-participating households is a non-participant in the market. The figure also shows the estimated density of the predicted probabilities that a bean market participating household is a non-participator. Neither of the estimated densities of the predicted probabilities have much mass near 0 or 1. In addition, the plot indicates that the estimated densities for each of the predicted probabilities have most mass in regions that in which they overlap. Thus, the IPWRA for bean model did not violate the overlap assumption.

The over-identification test for covariate balance results for the bean model is presented in Appendix 8.2. The test statistic (χ^2 = 2.54044; p= 0.9999) show that the IPWRA bean model does not violate the balanced covariates assumption.

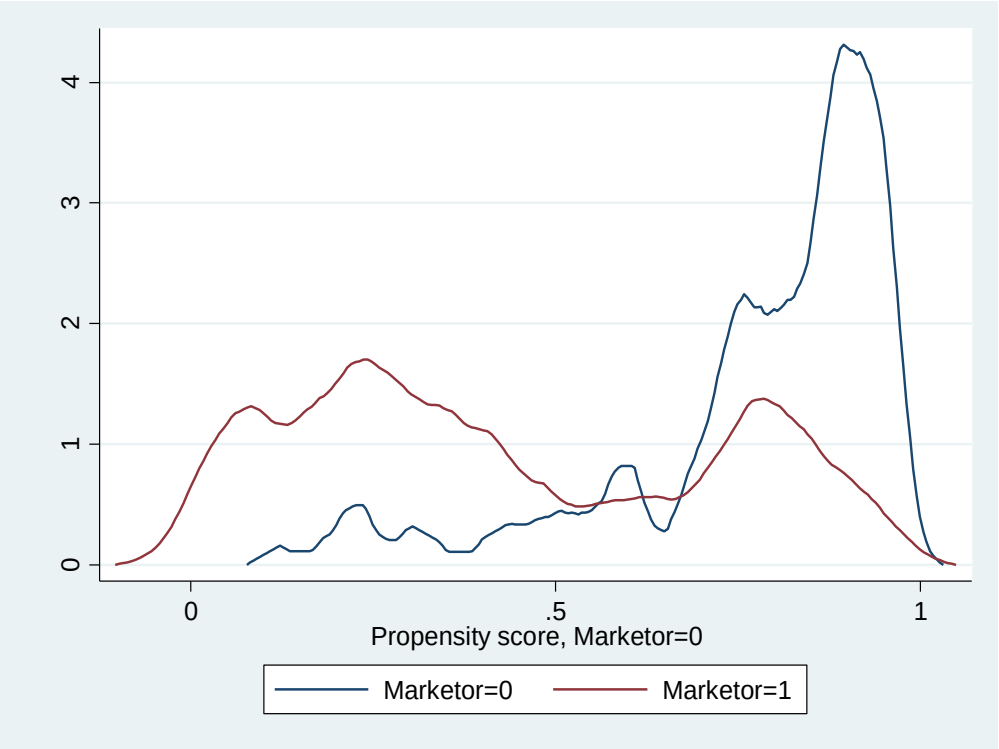

Figure 11: Estimated density of the predicted probability for bean farmers

Potato model diagnostics

Results presented in Figure 12 indicate that the estimated densities for households participating in the potato market have most of its probability mass near zero. However, the estimated density for households not participating in the potato market has not much probability mass near 0 or 1. Furthermore, the two estimates densities have very little mass in the region in which they overlap. These indicates the possibility that IPRWA for potato model violated the overlap assumption. However, this is not a point of concern since IPWRA estimates are consistent when either outcome model or treatment model is misspecified (Cattaneo, 2010). The over-identification test for covariate balance results for the bean model are presented in Appendix 8.3. The test statistic (=1.17418; p=1.0000) show that the model does not violate the balance of covariate assumption.

4.6.2. Results from IPWRA model estimation

The Average Treatment Effects (ATE) estimates using IPWRA and nearest neighbour matching are presented in Table 23. The positive sign on the ATE estimate indicates an increase in the probability of on-farm employment resulting from market participation in bean and potato output markets. The expected on-farm employment for farmers participating in output markets (0.348) is almost two times the expected on-farm employment of non-market participating farmers (0.188). Participation in bean and potato output markets increases on-

farm employment by 16%. The treatment effect with respect to Nearest Neighbour Matching (NNM) was positive and statistically significant at 10% level of significance. However, the magnitude of the Average Treatment Effects on the Treated (ATET) using NNM is 1.5 times bigger that IPRWA ATET estimate. NNM results show that employment increases by 24.4% due to households' participation in bean and potato output markets. The evidence suggests that market participation increases household generation of on-farm employment in rural economies.

Table 25: Overall average employment effects (ATE) using NNM and IPWRA

Matching Estimator	Outcome variable	Market participants	Non-participants	ATE
IPWRA	On-farm employment	0.348	0.188	0.160***
NNM	On-farm employment			0.244***

Note: NNB = Nearest Neighbour Match (Logit)

The interest of the study was also to establish the potential impact of market participation on employment creation by farmers who participated in the output market and their counterfactuals. This required estimation of the average treatment effect on the treated (ATET). Table 24 presents the ATET for bean and potato market participation. In the pooled sample, households that participated output market generated 19% more on-farm employment than they would have generated without market participation. Turning to the NNM, the probability of on-farm employment was 29.7% higher than their counterfactual situation.

Table 26: Overall average treatment effect on the treated (ATET) using NNM and IPWRA

Matching Estimator	Outcome variable	Market participants	Counterfactual	ATET
IPWRA	On-farm employment	0.447	0.248	0.199***
NNM	On-farm employment			0.297***

Note: NNM = Nearest Neighbour Match (Logit)

It was important to estimate the potential effect of the individual crop on the creation of on-farm employment. Table 25 presents the IPWRA and NNM ATE estimates of on-farm employment for farmer participation in the bean market. The difference in the probability of on-farm employment between the participation and non-participation in the bean market is 0.125. This show participation in the beans market increases on-farm employment by 12.5%. The NNM results indicate an ATE of 17.6%. This implies that participation in the beans market increases the probability of on-farm employment by 17.6%. These results provide evidence of the potential effect of bean market participation on on-farm employment.

Table 27: Bean average employment effects (ATT) using NNM and IPWRA

Matching Estimator	Outcome variable	Market participants	Non-participants	ATE
IPWRA	On-farm employment	0.278	0.152	.125**
NNM	On-farm employment			0.176***

Note: NNB = Nearest Neighbour Match (Logit)

Table 26 presents the ATET of bean farming households. The IPWRA ATET is statistically insignificant. This implies that there was no statistical differences in the probability of on-farm employment between market participating households and its counterfactual for bean crop. However, NNM result is statistically significant. This implies that participation in the bean output market increased the probability of on-farm employment by 26.9% than it would have been with a counterfactual situation

Table 28: Bean average treatment effect on the treated (ATET) using NNM and IPWRA

Matching Estimator	Outcome variable	Market participants	Counterfactual	ATET
IPWRA	On-farm employment	0.389	0.278	0.111
NNM	On-farm employment			.269***

Note: NNB = Nearest Neighbour Match (Logit)

Table 27 and Table 28 shows the ATE and ATET for potato market participation, respectively. Results in Table 27 shows the probability of on-farm employment (0.450) for participating in the potato market is almost four times the probability of on-farm employment for non-participation (0.141). The ATE is significant at 1% level of significance. This implies that participation in potato market increases the probability of on-farm employment by 30.9%. The ATE estimate from NNM is almost equal to the IPWRA ATE estimate. NNM ATE estimate shows that participation in the potato market increases the probability of on-farm employment by 30.5%.

Table 29: Potato average employment effects (ATT) using NNM and IPWRA

Matching Estimator	Outcome variable	Market participants	Non-participants	ATE
IPWRA	On-farm employment	0.450	0.141	0.309***
NNM	On-farm employment			0.305***

Note: NNB = Nearest Neighbour Match (Logit)

Results in Table 6 also indicates that the probability of employment generation (0.476) for potato market participation is almost four times the probability of on-farm employment for non-participation (0.116). This translated into ATE of 0.359. This result implies that potato market participants generated 35.9% more on-farm employment than they would have generated without participating in the market. The NNM ATET estimate is almost equal to the IPWRA. The NNM ATE estimate suggests that farmers who participated in the potato market generated about 33.33% more on-farm employment than they have generated without participating in the market.

Table 30: Potato average treatment effect on the treated (ATET) using NNM and IPWRA

Matching Estimator	Outcome variable	Market participants	Counterfactual	ATET
IPWRA	On-farm employment	0.476	0.116	0.359***
NNM	On-farm employment			0.333***

Note: NNB = Nearest Neighbour Match (Logit)

As highlighted by Oya (2013) and Blanc *et al*. (2008), the literature on on-farm wage employment is scarce, and this limited the chances of finding comparable research to this study's findings. However, the positive impact of smallholder market participation on on-farm employment found in this study is line with Dürr (2016) in his study in Guatemala. The latter author showed that smallholder households have the potential to generate more employment compared to large-scale farms. He recommended developing smallholder value chain as it favours employment creation among the poorest in the rural population. The results are also consistent with Scott (1981) who explored the effect of agrarian transformation in Peru and found that the volume of employment among the poor has increased with the transformation. Evidence by Barmon *et al*. (2004) confirmed that changes in a farming system affect the households' labour demand in their study on rice in Southwest of Bangladesh. The authors attributed this to the use of new agricultural technology.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1. Summary of the findings

The results showed 62% of the households that have purchased their inputs from the local market. The households that bought their inputs from farmers' cooperatives were 24%. For beans, 74% of households sold their produce through local market while 52% of potato producers sold through their cooperative. In the pooled sample 56% of the households have participated to output market with higher participation among potato producing households (80% versus 34% for beans). Only 14% and 60% of bean and potato producing households respectively, could be qualified as market oriented. Qualitative findings revealed that, potato is produced for the market, and it is a men' crop, while beans are mainly for subsistence and remains a women's crop. The study identified three gender-related issues that limit women's integration in the marketing systems and consequently affect the participation of their households in output market. These are: women's low participation in the input and output markets, women's limited control over agricultural income and their workload that increases as they combine farm work and their usual reproductive work.

Results showed that an increase in women's education level by 1 year would increase the likelihood of households' market participation and the intensity of participation by 1.6 % and 1.5% respectively. The same positive effect on households' market participation was also found when a woman is a member of group or possesses a mobile phone. Households that are headed by men were found to be more likely to participate in the potato market. In households where the crop was fully managed by a woman, the probability of potato market participation was likely to reduce while for beans, only the intensity of participation was found to be negatively affected. For potato, the women's limited access to productive resources could explain these gender differences in households' decisions to participate in the market. In bean producing households, the low degree of participation could result from their lower bargaining power or from the fact that the crop is mainly produced for consumption. Intra-household negotiations may not affect the participation intensity of potato farmers because the crop is already a man's crop. Households with women who had trainings were also likely to participate in bean market. Landholding, access to all-weather road and agricultural income from previous seasons as well as the market price were positively related to the market participation.

The findings also showed that households that sold a half or more of their output have higher chance to be in higher categories of food access compared to those who have not participated

in the market. Bean producing households have higher chances to shift to better food access status even when they sell less than a half of their produce. For both crops, market participation would worsen the food access status of households that are already food insecure. Households that engaged women in their decisions on the quantity of output sold have more probability to ameliorate their food access status compared to those who do not involve women. There was a positive effect of women's education and savings on food access status.

The findings from this study also revealed an increase in the probability of on-farm employment creation resulting from households' participation in bean and potato output markets. In the pooled sample for example, households that participated in output market generated 19% more on-farm employment than they would have generated without participation. The expected probability to have on-farm employment among the participating households was found to be double of the one among non-participating households (0.348 versus 0.188).

5.2. Conclusion

Based on above findings, the study led to the following conclusion:

1. The marketing system of the two crops is not yet developed with local market and cooperative being the key actors working with the households. The participation to output market is low and gender inequalities faced by women farmers play a considerable role in this.
2. Education level, agricultural trainings, membership in groups and possessing a personal mobile phone among women farmers improve their access to information, enhance their bargaining ability within households and therefore increase the probability of their households' participation in output market. Big land size, use of modern inputs as well as agricultural income from previous season have a positive effect in the households' decision to participate in output markets.
3. Market participation increases food access. However it would worsen the food access status among those who are already severely food insecure. Women's education, savings and their participation in agricultural decisions improve their households' food access.
4. Market participation has a positive impact on on-farm employment.

5.3. Recommendations

1. This study recommends to increase the level of organisation for bean crop and to strengthen the available links between the various actors in the marketing system for both crops. Various stakeholders in the agricultural sector should sensitize about the importance of women's participation in decision making on agricultural production and commercialisation.

2. The study recommends encouragement and facilitation of women's membership to groups, use of mobile phone, and training to access relevant agricultural knowledge an information. Campaigns on men and women equality and complementarity in agricultural decisions should be specifically organised to target smallholder households. It also recommends to improve the quality and number of roads, the use of improved inputs and more source of income for higher participation to output markets.

3. This study also recommends to continue the efforts of promoting market orientation in order to improve food access among smallholder households. Precautions should be taken for households that are already severely food insecure. Women farmers should be encouraged and facilitated to make savings to improve their households' food access.

4. The efforts to increase market participation level should be kept in order to increase opportunity of on-farm employment creation. Finally as cross-cutting factors, women's education and land size should be considered. This study recommends adult education that would increase women's access to knowledge. In regard to household landholding, the study recommends to reduce the number of households that depend on agriculture by facilitating non-farm employment creation in the research area.

5.4. Further research

1. The scope of this study did not allow a detailed analysis of other actors in the marketing systems, except the smallholder households and women farmers. An in-depth gender analysis of the other actors, is necessary to identify various leverage points for market orientation should be done.

2. The study was limited to the effects of output market participation. A research on the impact of input market participation in smallholder households would be very interesting. It could help to figure out the factors that shape the use of purchased inputs as well as their effects within farm households.

3. The present study only looked at food access which is one of the four dimensions of food security. A comprehensive study on food security is needed. In the same way, an analysis of how market participation affects off-farm employment could be interesting.

4. Findings from this study indicated some gender issues within farm households. A detailed study on the gender gap and women empowerment in Rwandan agriculture should be done.

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APPENDICES

APPENDIX 1: Summary of the elements of marketing systems on the focus

Aspect of marketing systems	Focus of the study
1. Economic and social structures	- Identifying the stakeholders: Farmers, intermediaries, retailer, farmers' organisations, traders, private companies, processors -Primary system: Exchanges facilitating the flow of two major crops in the area (beans and potato) at the research time. -Other systems: Exchanges of financial services, technology and knowledge (training, inputs), logistic (transport) and information.
2. Components of the systems	-Describe the roles of stakeholders
3. Supporting environment of the system	-Government strategies shaping the emerged systems -Formal service providers: Financial institutions, Research and extension institutions, Supporting NGOs. -Informal institutions: other groups outside the marketing systems. -Other factors: perceptions, past experiences, gender as a social construct.

APPENDIX 2: Questionnaire for household survey

Introduction

The aim of this study is to analyse market participation and its impact on rural employment and food security in the Northern Province. You have been randomly selected to participate in this survey and your VOLUNTARY participation is highly appreciated. Please note that your opinion will be completely CONFIDENTIAL and will be analysed together with those of others.

Module A: Household identification

Household Identification	**Number/Code**		**Interview details**	**Code**
A01: Household identification			**A13:** Start time of interview (hh:mm)	[ ][ ] : [ ][ ]
A02: GPS coordinates GPS **Lat …….……** **Lon…….**			**A14:** Date of visit (dd/mm/yy)	[ ][ ][ ][ ][ ][ ]
A03: Listing number			**A15:** Name and code of enumerator	[ ][ ][ ][ ][ ]
A04: District				
A05: Sector:				
A06: Cell				

A07: Name of primary respondent Surname First name			**Code 1** 11 Household head (man) 12 Household head (woman) 21 Children above 18		**Code 2** 1 = male and female headed 2 = female headed only 3 = male headed only
A08: Status in household in relationship to the household head: **Code 1**					
A09: Cell phone number :					
A10: Type of household : **Code 2**					

Module B: Household listing and demographics.

(*The respondent should be the one most knowledgeable about the age, completed education, and other characteristics of household members).*

B01: How many people are living in this household during the last 12 months?

B02: We would like to ask you about each member of your household. [*Respondent ID in relation to the household head (****Code 2****)]:*

Name of household member [start with primary respondent, continue with the secondary respondent, and other members in descending order of age]		What is [NAME's] sex?	What is [NAME's] relationship to the head of household?	What is [NAME's] age? (in complete years)	What is [NAME's] marital status?	What is [NAME's] main occupation	Can [NAME] read and write?	Is [NAME] currently attending school?	What is the highest level of education completed by [NAME
		Code 1	**Code 2**		**Code 3**	**Code 4**	**Code 5**	**Code 6**	**Code 7**
B03		**B04**	**B05**	**B06**	**B07**	**B08**	**B09**	**B10**	**B11**

Module Cb: Non-farm self-employment

Cb0: Has anybody in this household some self-employment activities during last 12 months?

If no skip to next section, if yes display a list of HH members to select from for the following section

Code of household member? Gender should be included	Describe the main self-employment activity	Type of employment	Is there a link with the market oriented agriculture?	Ownership of the self-employement activities?	Is this job permanent or seasonal or irregular/casual?	If irregular/casual, how much he/she earn per day?	If irregular/casual, how many working days per months?	If seasonal or permanent, how much does he/she earn per month?	If seasonal, how many working month per year?	Since when is she/he involved in these self - employment/work activities?
Code 2	**Code 3**	**Code 4**	**Code 5**	**Code 6**	**Code 7**					**Code 8**
Cb1	**Cb2**	**Cb3**	**Cb4**	**Cb5**	**Cb6**	**Cb7**	**Cb8**	**Cb9**	**Cb10**	**Cb11**

Code 1 1 = yes 0 = no	**Code 2** 11 Household head (man) 12 Household head 21 Children above 18 22 Children below 18 31 Grandson 41 Mother 42 Father 43 Mother in Law 44 Father in Law 51 Nephew/ nieces 61 Brothers and sisters in law of HH heads 71 Other relatives 81 Maid 91. Others (specify)	**Code 3** 1 Retailer 2 Driver/Raider 3 Health sector 4 Trainer/Advisor 5 Charcoal burner/selling 6 Brewing/selling of beer 7 Handicraf 8 Selling phone credit 9 Trader 10 Other (specify)	**Code 4** 1.Skilled Non-farm 2.Formal Non-farm 3.Unskilled Non-farm	**Code 5** 1 = yes, indirectly 2= yes, in the sector itself 0 = no	**Code 6** 1 Single ownership 2 Shared ownership 3 Ownership belongs to the spouse	**Code 7** 1 Seasonal 2 permanent i 3 Casual work/irregular (when needed)	**Code 8** 1. One year or less 2. One to five years 3. Six to 10 years 4. More than 10	

Module Cc Permanent employment creation:

Cc1: Do you or somebody in your household have any permanent employee
(**Do not include seasonal agricultural worker or casual worker paid on a daily basis in this table)**? **Code 1**
Cc2: How many permanent employees do you have? Number:

If yes mention for which activity ? If there are two (maids in the same household list them all)	Is this activity linked to market oriented agriculture?	Who is employing this person?	What is the gender of this worker?	Why do you have chosen women/men?	What is the age of the employee?	How much does he/she earn per months?	What kind of contract does he/she have?	Do you provide some extras?More than 1 answer possible	How many working hours per day of work?	How many working days per week?	Since when is this person employed?
Code 2	**Code 3**	**Code 4**	**Code 5**	**Code 6**			**Code 7**	**Code 8**			**Code 9**
Cc3	**Cc4**	**Cc5**	**Cc6**	**Cc7**	**Cc8**	**Cc9**	**Cc10**	**Cc11**	**Cc12**	**Cc13**	**Cc14**

Code 1 1 = Yes 0 = No	**Code 2** 1. Maid / Cook / Nanny/housekeeper (care sector) 2. Agricultural worker (general / clearing	**Code 3** 1.Yes, indirectly 2.Yes, in the sector itself, 3.No	**Code 4** 11 Household head (man) 12 Household head (woman) 21 Children above 18 22 Children below 18 31 Grandson 41 Mother 42 Father 43 Mother in Law	**Code 5** 1= female 2= male	**Code 6** 1 It is a women task 2 Women work harder 3 Women perform	**Code 7** 1. Written contract 2. Oral contract (regular)	**Code 8** 1. Meals / drinks 2. Insurance (health or	**Code 9** 1. One year or less 2. One

98 = I don't know 99 = No answer	weeds) 3. Agricultural worker (processing) 4. Agricultural worker (harvest only) 5. Agricultural worker (field supervising) 6. Agricultural worker (sowing) 7. Livestock (Cowboy) 8. Off-farm income generating activities like shop assistance. 9. Multitask domestic workers 5: Other (specify)…		44 Father in Law 51 Nephew/ nieces 61 Brothers and sisters in law of HH heads 71 Other relatives 81 Maid Others (specify)		better than men 4 Women have a smaller salary 5 Easy to work with women 6 It is a men task 7 Men work harder 8 Men perform better 9 Easier to work with men 10.Others	4. On call only (more than one response possible) _____	accident) 3. Transports 4. Pre-paid card (phone) 5. Housing 6. Clothes 7. Other Specify	to five years 3. Six to 10 years 4. More than 10 years

Module Da: Land and Land tenure

Land and access to land for production		Size / area of land in hectare	Unit 1.Ha 2.m2 3.Are	Type of ownership	How did you acquire this Land
				Code 2	Code 3
				1	2
Da1	Do you own any land?(Total owned land) Code 1				
Da2	if yes, what is the total surface that you own for agricultural production?				
Da9	Do you have any home gardens? **Code 1**				
Da10	Do you have any land GIVEN or LEASED to a cooperative? If yes, give the size of land?				
Da11	Do you rent out (LEASE) some land to other people? If yes, give the size of said land?				
Da12	Land given to land consolidation				

Module Db: Production and Marketing: Season 2015B

Three main crops cultivated by the household during Season 2015B If no crops cultivated skip to next page	Who was in charge of this crop?	Areas cultivated (in hectares, indicate if other measures)	Total production (In kg)	Production kept by the household for own consumption (in kg)	Production kept for seed and donation (In kg)	Production sold (In kg)	What was the Price per kg sold?	How was the price negotiated?	Where was it sold? (more than 1 answer are possible)	To whom was it sold?	Who from the household sold the crops?
Code 1	**Code 2**							**Code 3**	**Code 4**	**Code 5**	**Code 2**
Db1	**Db2**	**Db3**	**Db4**	**Db5**	**Db6**	**Db7**	**Db8**	**Db9**	**Db10**	**Db11**	**Dd12**

Code 1	**Code 2**	**Code 3**	**Code 4**	**Code 5**
1: Maize 2:Irish Potatoes 3: Wheat 4 Rice 5: Pyretrum 6: Plantain 7. Cassava 8. Cabbages/tomato/ other vegetables 9.Beans 10.Sweet potato 11.Other (specify)	1 Male household head 2 Female household head/wife 3 Both spouses 4 Other males household members 5.Other female household members	1: Prices negotiated **BEFORE** the harvest (contract farming) 2. Prices negotiated **AFTER** the harvest 3. Fixed prices set up yearly (for example cooperatives) current price of the market for this commodity	1 At farm/field 2 Local Market 3 Regional Market 4 National Market 5 Export) 6.Cooperative	1.Local market 2. Cooperative 3. State - regional authority 4. Private company 5. Other intermediary (local traders) 6. Family / friends or

Dd. Detailed use of main inputs in crops production (maximum 3 crops)

Code/name of the crop Kode / (Code1)	Type of inputs	Source of this input	If bought, by who?	Estimated amount/number per season	Unit	Approximated cost per season
Dd1	Dd2	Dd3	Dd4	Dd5	Dd6	Dd7
Code 1	**Code 2**	**Code 3**	**Code 4**		**Code 5**	
Code 1 1: Maize 2:Potatoes 3: Wheat 4. Rice 5: Pyretrum 6: Plantain 7. Cassava 8. Cabbages/Tomato/ other vegetable 9.Beans 10.Other (specify)	**Code2:** 1.Pesticide 2.Chemical fertiliser 3.Seeds 4.Manure 5.labour	**Code3:** 1.Local market 2.Own 3.Cooperative 4.Other farmers(donation) 5. RAB 6.NGO 7.Family members 8. Hired labour 9.Other specify	**Code4:** 1 Male household head 2 Female household head/wife 3 Both spouses 4 Other males household members 5.Other	**Code5:** 1.Kg 2. L 3. Number		

Module F: Assets. Fa: Vehicles & Energy

Do you have any vehicles?	How many units?	Who is the owner of this vehicle?	How many units of this item did you have 5 years ago?	Is your household equipped with one of the following item? Code 2 Fa4	How many?
		Code 1			
	Fa1	Fa2	Fa3		Fa5
Car				Electricity (grid-line)	
Motorcycle				Electricity (illegal coupling)	
Bicycle				Solar Panel	
Tractor				Water tank	
Truck / UV				Water pump	
				Water hole	
				Water fetching from roof top	

Code 1	**Code 2**
1 male household member 2 female household member 3 shared ownership	1 = yes 2 = no

Module G. Food access and availability

G.1.What is the main source of your household food? [ ] 1= Own-farm production, 2=Nearest Market, 3= Wage (working for food), 4= Food aid, 5=other families/relatives.

G.2. Number of months, when you did not have enough food to meet your family's needs (cut the size of your meals)….

G. 3. Which months do you have food shortage :
1=Jan.,2=Feb.,3=Mar.,4=Apr.5=May,6=Jun,7=Jul.,8=Aug.,9=Sep. 10=Oct.,11=Nov.,12=De
(Multiple answer are possible)

Question	Answers 1=yes, 0=no	**If yes**, how many times did this happen		
		Rarely (1 or 2 times) 1=yes, 0=no	Sometimes (3 to 10 times) 1=yes, 0=no	Often (more than 10 times) 1=yes, 0=no
Lb4. In the last month (4weeks), did you worry that your household would not have enough food?				
Lb5.In the last month (4weeks), were you or anybody in your household not able to eat the kind of food you preferred because of low production or lack of money to buy it?				
Lb6. In the last month (4weeks), were you or anybody in your household have to eat a limited variety of food due to low agricultural production or lack of money to buy it?				
Lb7. In the last month (4weeks), were you or anybody in your household have to eat the food you really do not want to eat because of lack of enough agricultural production or lack of money to buy food?				
Lb8. In the last month (4weeks), were you or anybody in your household have to eat smaller meal than you felt you needed due to low agricultural production or lack of money to buy food?				
Lb9. In the last month (4weeks), were you or anybody in your household have to take fewer meals in a day because there was not enough food in the household?				

Lb10. In the last month (4weeks), was there ever no food to eat of any kind in your household because of lack of agricultural production or money to buy it?				
Lb11. In the last month (4weeks), did you or any of your household gone to sleep in the night without eating because of lack of enough food?				
Lb12. In the last month (4weeks), did you or any of your household gone to sleep in the night without eating because of lack of enough food?				

Module H. Organisations

H.1. With which organizations do you work with?

Name of structure/ organisation	Structure / organisation type (**Code1**)	Since which year?	Type of relationship (**Code2**)	Duration of relationships **(in years)**	Still benefiting from the aid? ***1= Yes, 0= No***	**If no,** year of end of relationship	If no, why? (**Code 3**)	**If No,** since when is it non-operational?(year)

Structure/organization (Code1): *1= National Agricultural Research or Extension Institution, 2= NGO, 3= Government Project, 5= Farmers' organization, 6= Water and Forestry, 7= International Agricultural Research Institution, 8= Microfinance Institution, 9= Bank, 10= Informal saving groups,11= Agricultural private Company, 12=Non-agricultural private company,13=Other (specify)*

Relationship-type (Code2): *1= seed donation, 2= seed purchase by the institution, 3= sale of seed by the institution, 4= technical advice dispensed by the institution, 5= training, 6= credit in kind 7= credit in cash, 8= equipment allocation (farming equipment), 9= sales of fertilizers, 10= In-kind donation, 11= In-cash donation, 12= Employment, 13=other (specify),*

Code3: 1= End of their activities,2= Contract terminated in good terms, 3= Disagreement with the organization, 4= stopped by the household due to difficult conditions.

H.2. Has the household head ever attended a training related to 1= Agriculture, 2=Entrepreneurship, 3= Employment creation

H.3. If yes, who was the organizer of the training?

Structure/organization (Code1): *1= National Agricultural Research or Extension Institution, 2= NGO, 3= Government Project, 5= Farmers' organization, 6= Water and Forestry, 7= International Agricultural Research Institution, 8= Microfinance Institution, 9= Bank, 10= Informal saving groups,11= Agricultural private Company, 12=Non-agricultural private company,13=Other (specify)*

Module I: Information on infrastructure and extension services

Ia. Access to infrastructure

What is the distance to	Number of Kilometre	Means of transport
	Ia1	**Ia2**
		Code 1
Nearest market		
Nearest Boarder		
Nearest track road (usable throughout the year)		
Nearest center /small town		
Code 1: 1=By foot, 2= Bicycle, 3=Motobike, 4= Vehicle (paid bus)		

Ib. Access to extension services

Have you ever been visited by an extension officer (or agronomist) to advise on agricultural production?	If yes, how many times per season?
Ib1	**Ib2**
Code 1	
1 = yes 0 = no	

APPENDIX 3: Focus Group Discussion Check List

Thematic section	**Narrative Questions**	**Supplement Question**	**"Checklist" questions**
1.Transformation to commercial agriculture	1. Could you describe how the transformation to agricultural commercialisation is going in this location?	1.1. If you think about the last 10 years have there been any changes in references to agricultural commercialization?	1.1.a.What does the transformation towards commercialization means for you? 1.1.b. In reference to agricultural commercialization, what have changed in your households (production, harvesting, processing, and commercialization, consumption relationship with others and within household)? 1.1.c. Are there crops reserved for this transformation If yes which ones and why?). 1.2.a. What is the current level of commercialization in your household 1.2.b. What is the current impact on livelihoods (job, income) and food security?
		1.2. Could you describe the current situation about agricultural commercialization in your household?	

			1.2.c. What are the constraints do you face in the process of this transformation from outside the household (Production, processing, commercialization) ? 1.2.d. What are the constraints do you face in the process of this transformation from inside the household (some disagreement, time management, …) ?
		1.3.What do you think about the agricultural transformation policy in our Country?	1.3.a. What do you know about the agricultural transformation policy? 1.3.b. From where/whom do you have this information? 1.3.c. Do you think it is the best option to combat poverty and food insecurity?

2.Marketing Channels	2.1. Could you describe the process of commercialization of your products? (Where commercialization occurs and please specify the crop you are talking about)	2.1. How do you sell (seek to know the channels) your agricultural products?	2.1.a. To whom do you sell your agricultural production? 2.1.b. How often do you sell your products (also the quantity taken to the market)? 2.1.c. In the household, who mostly deals with the buyers and why? 2.1.d. Do you sometimes negotiate the price before harvest (When do they negotiate price)?
	2.2. Could you describe your relationship with the buyer of your agricultural products (specify crops)?	2.2.a. Could you describe your relationship with the buyers of your products? 2.2.b. What do you observe in your village about the relationship between buyer and farm household sellers? 3.1.b. Could you describe their roles in the agricultural transformation in your area(describing other farmers case)?	2.2.a. Do you know them even before the harvest of your products ? 2.2.b. Do you have any kind of agreement related to production, processing or commercialization (includes transport) of your products? 2.2.c. Do you receive any support from them?

4. Gender	Could you tell us what you think should be done for to accelerate the transformation to commercial agriculture in your area?	4.1. Could you tell us what you think should be done to increase the market participation and commercialisation level in your household (seek to understand the need)? 4.2. Could you tell us what you think should be done to increase the market participation and commercialisation level in this area (seek to understand the need)? 4.3.Do women and men have the same needs ?	4.1. Within household: at Production, processing and commercialization level? 4.2. At community level: Production, processing and commercialization level? 4.3.a. Please describe what you think are the women' needs. 4.3.b. Please describe what you think are the men' needs.

APPENDIX 4: Candidate's publications related to this study

1. Agricultural transformation in Rwanda: Can gendered market participation explain the persistence of subsistence farming?

Published in *Gender and Women's Studies, Vol.2 (1)*, pp.1-18

Abstract

Despite the efforts to agricultural transformation in Rwanda, farming systems are predominantly still in subsistence production. Women are more involved than men, and their number in has even increased in the past decade. The reasons for this remain unclear, given the country's efforts for gender mainstreaming towards market-oriented agriculture. Guided by the current debate on feminization of agriculture, we base this study on the thesis that higher market participation among women farmers could contribute to this transformation. The study uses the case of the Northern Province of Rwanda. It involved 368 smallholder dual-headed households among which 208 and 160 were respectively producing beans and potato. It used a mixed method approach with sequential exploratory design, involving a quantitative survey households followed Focus Group Discussions (FGDs). Both Household Commercialization Index (HCI) and Thematic Analyses were used. Findings showed a high degree of commercialization for potato, with 75% of farmers participating in output markets, and 72% among them being market oriented. In contrast, only 26% of bean farmers sold their production. The commercialization of potato is in the hands of men, while beans are mainly sold by women. This was also confirmed with the findings from FGDs. Three issues were identified as hindrances to agricultural transformation and likely to keep households in subsistence production: the low participation of women in input and output markets; their limited control over agricultural income; and their increased workload that combines on-farm and reproductive works. Therefore, despite the efforts at policy level, there are still gender inequalities within dual-headed farming households, and the agricultural transformation risks increasing the gap through all or some of the three identified issues. Removing these inequalities could increase households' market participation and contribute in the process of agricultural transformation.

Key words: Agricultural transformation; Markets; Women; Gender; Mixed Methods; Rwanda

2. Towards Commercial Agriculture in Rwanda: Understanding the Determinants of Market Participation among Smallholder Bean Farmers

Published in *African Journal of Food, Agriculture, Nutrition and Development, Vol.*17 (4), pp.12492-12508.

Abstract

Agricultural transformation is key to poverty reduction and food security in Sub-Saharan Africa (SSA). In Rwanda, this transformation has focused on shifting subsistence-based production to market-oriented farming. Over the last one and a half, a major emphasis has been placed on the intensification of production systems, promotion of farmer cooperatives, and enhancement of farmers' access to markets. Although the country recorded an increase in food crop commercialization, subsistence farming is still prevalent amongst smallholder farmers. Yet, in the few studies conducted on agricultural transformation, smallholder commercialization has received scanty attention. As the country aims to achieve commercialized agriculture, there is a need to understand what factors can influence farmers' decisions to participate in the output markets. This study analyses the levels of market participation and drivers of output commercialization, using a sample of 256 bean farmers from northern Rwanda. A double-hurdle model was used to analyse the data. Results indicated that 30% of the farmers participated in the market with an average commercialization index of 0.42. Land size, agricultural training and group membership of household head had a positive effect on households' participation to bean market. The distance to the nearest access road that can be used throughout the year, reduces the probability of commercialization at household level. The degree of market participation was positively influenced by price, education level of the household head and livestock income. On the other hand, distance to key markets had a negative effect on the degree of households' commercialization. The findings of this paper show that participation in bean markets is still low, with disparities in the commercialized quantities amongst those who participate. Female-headed households were more likely to participate in bean markets, selling higher volumes than male-headed households. This gender difference suggests that bean can be an important source of income for women smallholder farmers. The study recommends more efforts in improving road networks connecting to key markets, facilitating cross-border trade and increasing agricultural training amongst the farmers. Additionally, the use of improved inputs in bean production as well

as income diversification through livestock rearing should be encouraged. All the interventions should be gender-sensitive so as not to deny women their source of livelihood through bean production and marketing.

Key words: Agricultural transformation, Commercialization, Gender, Double-hurdle, Rwanda

APPENDIX 5: Tables from Double-Hurdle models estimation

Partial effect in Tier 1 for the Pooled sample

	Delta-method				
	dy/dx	Std. Err.	z	P>|z|	[95% Conf. Interval]
Agew	-.00233	.0011553	-2.02	0.044	-.0045945
genderhead	.031465	.0714916	0.44	0.660	-.108656
Educationw	.0396784	.0216249	1.83	0.067	-.0027056
Newmaritalw	.0199089	.0495401	0.40	0.688	-.0771879
Mainoccupationh	-.0150833	.0079512	-1.90	0.058	-.0306672
HHsize	-.0189912	.0080827	-2.35	0.019	-.034833
TotalandHa	.0969969	.0461667	2.10	0.036	.0065119
Impinputsh	.0853793	.0414225	2.06	0.039	.0041927
DecisTech					
Input into very few decisions	-.0141778	.0640592	-0.22	0.825	-.1397316
Input into some decisions	.0339838	.0638066	0.53	0.594	-.0910749
Input into most of decisions	-.0374397	.0688969	-0.54	0.587	-.1724751
Input into all decisions	-.0085346	.0603765	-0.14	0.888	-.1268704
incharg					
Female spouse of the hhh	-.1052573	.0490247	-2.15	0.032	-.2013439
Both spouses	-.0351312	.0454026	-0.77	0.439	-.1241187
Agtrainingw	.0255076	.0451016	0.57	0.572	-.0628898
Memgroupsw	.3586885	.0214725	16.70	0.000	.3166032

nvisitex	.0148806	.0208101	0.72	0.475	-.0259064
Distmarketh	.0158471	.0176993	0.90	0.371	-.0188428
Distroadh	-.0100942	.0168254	-0.60	0.549	-.0430714
Distborderh	-.026158	.0178904	-1.46	0.144	-.0612226
dist					
Gakenke	-.0712567	.0861808	-0.83	0.408	-.2401678
Musanze	.1425836	.0612138	2.33	0.020	.0226067

Partial effect in Tier 2 for the Pooled sample

	Delta-method				
	dy/dx	Std. Err.	z	P>|z|	[95% Conf. Interval]
Agew	-.0004402	.0011342	-0.39	0.698	-.0026632
genderhead	-.0907445	.0472753	-1.92	0.055	-.1834024
Educationw	.0354521	.0151709	2.34	0.019	.0057178
Newmaritalw	.0357008	.0404943	0.88	0.378	-.0436666
MainoccupationW	-.0026903	.0075127	-0.36	0.720	-.0174149
HHsize	-.0089741	.007231	-1.24	0.215	-.0231465
TotalandHa	.0501659	.0152728	3.28	0.001	.0202318
transasset	-.0194633	.0246508	-0.79	0.430	-.0677781
nocomassetsW1	.0736908	.0304762	2.42	0.016	.0139585
Livesth	-.0186286	.0277962	-0.67	0.503	-.0731081
MarkPriceh	.0001949	.0002338	0.83	0.404	-.0002633
Agtrainingw	.0564376	.033402	1.69	0.091	-.0090291
nvisitex	-.001919	.0120702	-0.16	0.874	-.0255762
Memgroupsw	.2124945	.0423702	5.02	0.000	.1294505
Distmarketh	.0177679	.0117818	1.51	0.132	-.005324
Distroadh	-.0064015	.0128745	-0.50	0.619	-.0316351

Distborderh	-.0148943	.0093944	-1.59	0.113	-.033307
Credith	-.0359796	.0331612	-1.08	0.278	-.1009744
lncropval_prod_hh	.0106917	.0030978	3.45	0.001	.00462
incharg					
Female spouse of the hhh	-.163504	.0349002	-4.68	0.000	-.231907
Both spouses	-.0130434	.0322195	-0.40	0.686	-.0761925
DecisQuant					
Input into very few decisions	-.04647	.0407069	-1.14	0.254	-.126254
Input into some decisions	-.0460507	.0493729	-0.93	0.351	-.1428198
Input into most of decisions	-.03651	.0642427	-0.57	0.570	-.1624233
Input into all decisions	-.1029277	.0502436	-2.05	0.041	-.2014033

APPENDIX 6: Tables from Ordered Logistic models estimation

Estimates for bean producers

Ordered logistic regression — Number of obs = 211

Wald chi2(18) = 133.00

Prob > chi2 = 0.0000

Log pseudolikelihood = -203.16184 — Pseudo R2 = 0.2562

FoodSEC	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
HCIcat						
Sold less than 50%	.7685603	.3837501	2.00	0.045	.016424	1.520697
Sold 50% or more	1.187311	.5827948	2.04	0.042	.045054	2.329568
Agew	-.0038126	.0130217	-0.29	0.770	-.0293346	.0217095
genderhead	.9343896	.5752902	1.62	0.104	-.1931584	2.061938
SchoolingW	.0977518	.0624788	1.56	0.118	-.0247044	.2202081
HHsize	-.0080249	.0908024	-0.09	0.930	-.1859944	.1699446
TotalandHa	1.510779	.4857872	3.11	0.002	.5586541	2.462905

MarkPriceh	.0023954	.0038784	0.62	0.537	-.0052062	.0099969
SelfemploNF	.63865	.9607112	0.66	0.506	-1.244309	2.521609
InformSaving	1.139465	.375106	3.04	0.002	.4042703	1.874659
Market	-.4043862	.3222868	-1.25	0.210	-1.036057	.2272843
climatehazard	.1903676	.7317021	0.26	0.795	-1.243742	1.624477
ShockIll	-.5091845	.3925388	-1.30	0.195	-1.278546	.2601774
lnTotalInco1	-.1617234	.0465465	-3.47	0.001	-.252953	-.0704939
DecisIncomeN						
Input into some decision	-1.05898	.8630285	-1.23	0.220	-2.750484	.6325251
Input into most/all decision	-1.129406	.6068146	-1.86	0.063	-2.31874	.0599291
DecisQuantN						
Input into some decision	.7546027	.670203	1.13	0.260	-.5589711	2.068176
Input into most/all decision	3.075278	.5951908	5.17	0.000	1.908726	4.241831
/cut1	1.806251	1.511286			-1.155816	4.768318
/cut2	3.694312	1.51701			.7210271	6.667598
/cut3	4.56041	1.528946			1.563732	7.557089

Estimates for Potato producers

Ordered logistic regression — Number of obs = 178

Wald chi2(18) = 74.65

Prob > chi2 = 0.0000

Log pseudolikelihood = -173.03774 — Pseudo R2 = 0.2373

FoodSEC	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
HCIcat						
Sold less than 50%	.524018	.5164738	1.01	0.310	-.4882521	1.536288
Sold 50% or more	1.395666	.3686679	3.79	0.000	.6730902	2.118242
Agew	.0025202	.0104064	0.24	0.809	-.017876	.0229164

genderhead	.0413793	.4193001	0.10	0.921	-.7804339	.8631924
SchoolingW	.1218593	.0706443	1.72	0.085	-.0166009	.2603196
HHsize	.0143625	.0693595	0.21	0.836	-.1215796	.1503047
TotalandHa	1.400726	.4137538	3.39	0.001	.5897837	2.211669
MarkPriceh	.0001372	.0041858	0.03	0.974	-.0080668	.0083412
SelfemploNF	-.5885307	.7960684	-0.74	0.460	-2.148796	.9717346
InformSaving	.8862816	.3807117	2.33	0.020	.1401003	1.632463
Market	.8262808	.4217334	1.96	0.050	-.0003014	1.652863
climatehazard	-.1242491	.7400137	-0.17	0.867	-1.574649	1.326151
ShockIll	-.0087094	.4056906	-0.02	0.983	-.8038484	.7864296
lnTotalInco1	-.2088194	.0407632	-5.12	0.000	-.2887138	-.1289249
DecisIncomeN						
Input into some decision	1.1236	.5698283	1.97	0.049	.0067572	2.240443
Input into most/all decision	.7668088	.3916441	1.96	0.050	-.0007996	1.534417
DecisQuantN						
Input into some decision	-.8104299	.5564844	-1.46	0.145	-1.901119	.2802595
Input into most/all decision	2.503477	.487408	5.14	0.000	1.548175	3.458779
/cut1	1.367686	1.266747			-1.115093	3.850465
/cut2	3.102463	1.293271			.5676977	5.637227
/cut3	3.999208	1.324744			1.402758	6.595658

Diagnostic tests for the parallel regression assumption (Brant test) - For the pooled sample

	chi2	p>chi2	df
All	111.94	0.000	36
1.HCIcat	0.24	0.889	2
2.HCIcat	1.38	0.501	2
Agew	1.20	0.548	2
genderhead	0.58	0.750	2

SchoolingW	2.52	0.283	2
HHsize	11.95	0.003	2
TotalandHa	1.40	0.497	2
MarkPriceh	2.75	0.252	2
SelfemploNF	0.87	0.646	2
InformSaving	2.71	0.258	2
Market	0.64	0.726	2
climatehazard	0.69	0.709	2
ShockIll	6.91	0.032	2
lnTotalInco1	9.75	0.008	2
2.DecisIncomeN	13.25	0.001	2
3.DecisIncomeN	19.78	0.000	2
2.DecisQuantN	4.72	0.095	2
3.DecisQuantN	30.93	0.000	2

A significant test statistic provides evidence that the parallel regression assumption has been violated.

APPENDIX 7: Tables from Generalized Ordered Logit Model for the Pooled sample

Generalized Ordered Logit Estimates — Number of obs = 389

Wald chi2(54) = 242.14

Prob > chi2 = 0.0000

Log pseudolikelihood = -326.74392 — Pseudo R2 = 0.3467

FoodSEC	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
Severely_fo~e						
_IHCIcat_1	.3042824	.423874	0.72	0.473	-.5264953	1.13506
_IHCIcat_2	1.150601	.384997	2.99	0.003	.396021	1.905181
Agew	.0064053	.010905	0.59	0.557	-.014968	.0277786
genderhead	.7032873	.4418479	1.59	0.111	-.1627186	1.569293

```
   SchoolingW |    .138645   .0569091     2.44   0.015     .0271051    .2501849
       HHsize |  -.0617287    .078183    -0.79   0.430    -.2149646    .0915071
   TotalandHa |   1.690406    .459652     3.68   0.000      .789505    2.591308
   MarkPriceh |   .0060101   .0035263     1.70   0.088    -.0009013    .0129215
  SelfemploNF |   -.782587    .689616    -1.13   0.256    -2.134209    .5690354
 InformSaving |   1.353977   .3059598     4.43   0.000     .7543069    1.953647
       Market |   .3526357   .3179141     1.11   0.267    -.2704646     .975736
climatehazard |  -.3082428   .5681979    -0.54   0.587     -1.42189    .8054046
     ShockIll |   -.693507   .3699341    -1.87   0.061    -1.418565    .0315506
 lnTotalInco1 |  -.2364008   .0411521    -5.74   0.000    -.3170574   -.1557443
_IDecisInco_2 |  -.5816401   .5976956    -0.97   0.330    -1.753102    .5898218
_IDecisInco_3 |   -.694062   .3819173    -1.82   0.069    -1.442606    .0544821
_IDecisQuan_2 |   .0115047   .4770213     0.02   0.981    -.9234398    .9464492
_IDecisQuan_3 |   4.062642   .5492301     7.40   0.000     2.986171    5.139113
        _cons |  -2.319299   1.338801    -1.73   0.083    -4.943302     .304703
--------------+----------------------------------------------------------------
Moderately_~e |
   _IHCIcat_1 |   .2457685   .4082037     0.60   0.547     -.554296    1.045833
   _IHCIcat_2 |   .8730163   .4012539     2.18   0.030     .0865732    1.659459
         Agew |  -.0218609   .0111603    -1.96   0.050    -.0437346    .0000129
   genderhead |   .9091808   .6065968     1.50   0.134    -.2797271    2.098089
   SchoolingW |   .0039839   .0558604     0.07   0.943    -.1055004    .1134682
       HHsize |   .2107171   .0636495     3.31   0.001     .0859664    .3354677
   TotalandHa |   1.690204   .4190705     4.03   0.000      .868841    2.511567
   MarkPriceh |   .0101767    .003236     3.14   0.002     .0038342    .0165192
  SelfemploNF |  -.6790419   .6118108    -1.11   0.267    -1.878169    .5200853
 InformSaving |    .981127   .3233883     3.03   0.002     .3472975    1.614956
       Market |   .3099379    .311628     0.99   0.320    -.3008417    .9207174
climatehazard |    .487255   .6691656     0.73   0.467    -.8242856    1.798796
     ShockIll |   -.025933   .3844392    -0.07   0.946      -.77942    .7275541
 lnTotalInco1 |  -.1718759   .0323649    -5.31   0.000    -.2353099    -.108442
_IDecisInco_2 |   .5741119   .4820097     1.19   0.234    -.3706097    1.518834
```

_IDecisInco_3	.2190595	.440835	0.50	0.619	-.6449612	1.08308
_IDecisQuan_2	-1.54075	.4833936	-3.19	0.001	-2.488184	-.5933157
_IDecisQuan_3	1.57984	.5071224	3.12	0.002	.5858982	2.573781
_cons	-5.464925	1.735939	-3.15	0.002	-8.867303	-2.062547
Mildly_food~e						
_IHCIcat_1	.433268	.5595486	0.77	0.439	-.6634271	1.529963
_IHCIcat_2	.0552409	.5081646	0.11	0.913	-.9407434	1.051225
Agew	.0004263	.0138971	0.03	0.976	-.0268115	.0276641
genderhead	-.0962875	.685353	-0.14	0.888	-1.439555	1.24698
SchoolingW	.2264205	.086937	2.60	0.009	.0560271	.3968139
HHsize	-.1033217	.1083556	-0.95	0.340	-.3156948	.1090514
TotalandHa	.2641516	.2756489	0.96	0.338	-.2761104	.8044136
MarkPriceh	-.0017135	.0039293	-0.44	0.663	-.0094148	.0059878
SelfemploNF	1.172228	.6013361	1.95	0.051	-.0063692	2.350825
InformSaving	.9610832	.4557606	2.11	0.035	.0678088	1.854358
Market	-.0845177	.4537978	-0.19	0.852	-.9739451	.8049098
climatehazard	.6030921	.5498609	1.10	0.273	-.4746155	1.6808
ShockIll	-.0135101	.5029123	-0.03	0.979	-.9992001	.97218
lnTotalInco1	-.0828371	.0363234	-2.28	0.023	-.1540297	-.0116445
_IDecisInco_2	2.96457	.734448	4.04	0.000	1.525078	4.404062
_IDecisInco_3	2.857158	.5219015	5.47	0.000	1.83425	3.880066
_IDecisQuan_2	.6184996	1.128967	0.55	0.584	-1.594234	2.831233
_IDecisQuan_3	.4419644	.5244691	0.84	0.399	-.585976	1.469905
_cons	-2.899517	1.488493	-1.95	0.051	-5.816909	.0178752

APPENDIX 8: Estimation of treatment effect with IPWRA

Appendix 8.1.Test for covariate balance for the pooled sample

```
Overidentification test for covariate balance
         H0: Covariates are balanced:
         chi2(16)     =  4.35128
         Prob > chi2  =   0.9991
```

Appendix 8.2.Test for covariate balance for beans producers

```
Overidentification test for covariate balance
         H0: Covariates are balanced:
         chi2(16)     =  1.17418
         Prob > chi2  =   0.9999
```

Appendix 8.3.Test for covariate balance for potato producers

```
Overidentification test for covariate balance
         H0: Covariates are balanced:
         chi2(16)     = 2.54044
         Prob > chi2  =   1.0000
```

Appendix 8.4. Treatment effect in pooled sample with IPWRA estimator

```
Treatment-effects estimation                   Number of obs     =        389

Estimator      : IPW regression adjustment

Outcome model  : logit

Treatment model: logit
```

		Robust				
Employment	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
POmeans						
Marketor						
0	.1878685	.037631	4.99	0.000	.1141131	.261624
1	.3477144	.0316276	10.99	0.000	.2857255	.4097034

```
Treatment-effects estimation                   Number of obs     =        389

Estimator      : IPW regression adjustment

Outcome model  : logit
```

Treatment model: logit

	Robust				
Employment	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
ATE					
Marketor					
(1 vs 0)	.1598459	.0474559	3.37	0.001	.066834 .2528578
POmean					
Marketor					
0	.1878685	.037631	4.99	0.000	.1141131 .261624

Appendix 8.5. Treatment effect in pooled sample with nearest neighbor matching

Treatment-effects estimation — Number of obs = 389

Estimator : nearest-neighbor matching — Matches: requested = 3

Outcome model : matching — min = 3

Distance metric: Mahalanobis — max = 4

	AI Robust				
Employment	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
ATE					
Marketor					
(1 vs 0)	.2444302	.0434994	5.62	0.000	.1591729 .3296874

	AI Robust				
Employment	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
ATET					
Marketor					

```
   (1 vs 0)  |   .2968992   .0478316     6.21   0.000     .2031511    .3906474
------------------------------------------------------------------------------
```

Appendix 8.6. Treatment effect for bean producers with IPWRA estimator

```
Treatment-effects estimation                    Number of obs     =        211
Estimator      : IPW regression adjustment
Outcome model  : logit
Treatment model: logit
------------------------------------------------------------------------------------------
                                |               Robust
                     Employment |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------------------------+----------------------------------------------------------
POmeans                         |
                       Marketor |
                              0  |   .1524456   .0341772     4.46   0.000     .0854595    .2194317
                              1  |    .277772   .0394131     7.05   0.000     .2005238    .3550202
------------------------------------------------------------------------------------------
Treatment-effects estimation                    Number of obs     =        211
Estimator      : IPW regression adjustment
Outcome model  : logit
Treatment model: logit
------------------------------------------------------------------------------------------
                                |               Robust
                     Employment |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------------------------+----------------------------------------------------------
ATE                             |
                       Marketor |
                     (1 vs 0)   |   .1253264    .049176     2.55   0.011     .0289432    .2217097
-------------------------------+----------------------------------------------------------
POmean                          |
                       Marketor |
                              0  |   .1524456   .0341772     4.46   0.000     .0854595    .2194317
------------------------------------------------------------------------------------------
```

```
Treatment-effects estimation                    Number of obs     =        211
Estimator      : IPW regression adjustment
Outcome model  : logit
Treatment model: logit
------------------------------------------------------------------------------------------
                                |               Robust
                     Employment |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------------------------+----------------------------------------------------------
ATET                           |
                       Marketor |
                     (1 vs 0)  |   .1105334   .0685082     1.61   0.107    -.0237403     .244807
-------------------------------+----------------------------------------------------------
POmean                         |
                       Marketor |
                              0  |   .2783555   .0570192     4.88   0.000     .1665999    .3901111
------------------------------------------------------------------------------------------
```

Appendix 8.6. Treatment effect in potato with nearest neighbor matching

```
Treatment-effects estimation                    Number of obs     =        178
Estimator      : IPW regression adjustment
Outcome model  : logit
Treatment model: logit
------------------------------------------------------------------------------------------
                                |               Robust
                     Employment |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------------------------+----------------------------------------------------------
POmeans                        |
                       Marketor |
                              0  |   .1405068    .032039     4.39   0.000     .0777115    .2033021
                              1  |   .4498564   .0406226    11.07   0.000     .3702375    .5294752
------------------------------------------------------------------------------------------
```

```
Treatment-effects estimation                   Number of obs     =        178
Estimator      : IPW regression adjustment
Outcome model  : logit
Treatment model: logit
------------------------------------------------------------------------------
                             |               Robust
                  Employment |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----------------------------+------------------------------------------------
ATE                          |
                    Marketor |
                   (1 vs 0)  |   .3093496   .0524271     5.90   0.000     .2065944    .4121048
-----------------------------+------------------------------------------------
POmean                       |
                    Marketor |
                           0 |   .1405068    .032039     4.39   0.000     .0777115    .2033021
------------------------------------------------------------------------------
Treatment-effects estimation                   Number of obs     =        178
Estimator      : IPW regression adjustment
Outcome model  : logit
Treatment model: logit
------------------------------------------------------------------------------
                             |               Robust
                  Employment |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----------------------------+------------------------------------------------
ATET                         |
                    Marketor |
                   (1 vs 0)  |   .3590869   .0534505     6.72   0.000      .254326    .4638479
-----------------------------+------------------------------------------------
POmean                       |
                    Marketor |
                           0 |   .1164375   .0317044     3.67   0.000     .0542981    .1785769
------------------------------------------------------------
```